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HUSBAND'S FORENSIC MEDICINE TOXICOLOGY AND PUBLIC HEALTH

SEVENTH EDITION, REVISED & ENLARGED

BY

R. J. M. BUCHANAN

M.D., B.Ch. (Vict.), M.R.C.P. Lond., M.R.C.S. Eng.

ASSISTANT LECTURER ON FORENSIC MEDICINE AND TOXICOLOGY IN THE UNIVERSITY OF LIVERPOOL; ASSISTANT HONORARY PHYSICIAN TO THE LIVERPOOL ROYAL INFIRMARY; FORMERLY HONORARY PHYSICIAN TO THE STANLEY HOSPITAL, LIVERPOOL; AND ASSISTANT HONORARY PHYSICIAN TO THE HOSPITAL FOR CONSUMPTION AND DISEASES OF THE CHEST, LIVERPOOL

AND

E. W. HOPE, M.D., D.Sc.

PROFESSOR OF PUBLIC HEALTH, UNIVERSITY OF LIVERPOOL; MEDICAL OFFICER OF HEALTH OF THE CITY AND PORT OF LIVERPOOL

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PREFACE TO THE SEVENTH EDITION

This edition has been carefully and entirely revised and many alterations and additions made. The work has been divided into sections and chapters, and the index elaborated for the purpose of rendering it more useful to the reader.

In the section on Forensic Medicine, amongst others, the articles on Legal Criminal Procedure, Medical Evidence, Modes of Dying, Burns and Scalds, and Starvation have been re-arranged and amplified. The chapter on Blood-Stains has been rewritten and attention given to the Biological Tests.

In the section on Toxicology the previous classification of poisons has been adhered to. In the description of the various poisons additional material has been introduced. The articles on Putrefactive Alkaloids, Leucomaines, and Food Poisoning are entirely new to this edition.

Considerable advances have been made in Public Health in recent years, and these have necessitated the rewriting of a number of the chapters, so as to bring them fully up to date. The reader will find a clear enough indication of the direction in which he must look if he wishes to make a more exhaustive study of the subject in order to fit himself for the duties of Medical Officer of Health. The work has been profusely illustrated in the hope of increasing its practical value to the reader. Apart from the general bibliography mentioned in the text the

works of Taylor and Stevenson, Dixon Mann, Luff, and Glaister have been consulted.

Every effort has been made to enhance the value of this edition as a handbook for students and general practitioners.

We desire to express our thanks to Messrs. Clay of the Cambridge University Press for permission to use the illustrations relating to Board Schools.

R. J. M. BUCHANAN,
E. W. HOPE.

LIVERPOOL UNIVERSITY,
January 1904.

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SECTION I.

FORENSIC MEDICINE.

INTRODUCTION.

Medical Jurisprudence, Forensic Medicine, or Legal Medicine are terms for that science which teaches the application of the knowledge of all branches of medical and surgical science and art to the solution of every question connected with the conservation of the species and the administration of Justice. We find traces of this science in the Jewish law; among the Egyptians, according to Plutarch; and even among the Romans as early as the times of Numa Pompilius. Among German writers the term State Medicine includes both Medical Jurisprudence and Medical Police, Public Health, or Sanitary Science.

The special knowledge requisite to the Medical Jurist differs in many ways from that requisite for the art of healing the sick. The majority of medical students and practitioners may consider a simple exercise of common sense in the application of their general professional knowledge to the elucidation of problems of medico-legal import all that is requisite, and that no special training is necessary for the purpose. They may hope that it may never fall to their lot to be called upon to act in the capacity of medical jurists. It may occur, however, to any medical practitioner at any time of his professional career that

his services be requisitioned by law for the purpose of elucidating problems of such a nature as will demand from him thought and judgment quite apart from those he exercises in the ordinary course of his medical and surgical practice. From such a requisition he has no escape: he cannot shift his responsibility to another, and it behoves him, therefore, to acquire a knowledge of Forensic Medicine, in order to guide him, when so called upon, to give such evidence as will enable a judge and jury to arrive at a just conclusion. The relations of all medical practitioners to the State are twofold—first, as healers of disease, and secondly, both as guardians of the innocent against unfounded criminal charges and aids towards the detection and punishment of crime.

CHAPTER I.

LEGAL CRIMINAL PROCEDURE.

ENGLAND AND IRELAND.

The Coroner's Court.—The office of coroner is mentioned in a charter in 925. Coroners were formerly chosen for life by the freeholders of the district, but their election is now in the hands of the County Councils. Their duties were first clearly pointed out by the Act 4 Edw. I. c. 2, 1275 (*De officio coronatoris*).

At the present time the duties of the coroner are chiefly to hold inquiry into the cause of death when there is any reason to doubt that death resulted from natural causes.

When death results from natural causes, and under ordinary conditions, the medical attendant is bound, under a penalty of forty shillings, to certify as to the cause. The registrar of deaths accepts such a certificate when accompanied by oral testimony given by a person who was present at the time of death, and issues a certificate accordingly, authorising the interment of the deceased.

Should conditions obtain to prevent the medical attendant from forming an opinion as to the cause of death, or which would lead him to infer that death did not take place from natural causes, he should notify the matter to the coroner. Such would be necessary if death were directly or indirectly due to accident, or if death occurred within a reasonable time after an accident, although due to some other cause, or if an accident happened to deceased during the course of a chronic illness, the accident, however, not in itself necessarily fatal.

It would be necessary also to notify the coroner if the death took place under circumstances which, to the medical attendant, appeared suspicious, such as might arise from culpable neglect

or cruelty on the part of persons in charge of the deceased. The same would apply to cases in which the cause of death was unknown. A great responsibility rests on the medical practitioner, in that he is compelled under a penalty to certify as to the cause of death; while if he do so without due consideration, or carelessly, he renders himself liable to censure or legal proceedings.

It may happen that in certain cases—for example, where an accident befell the deceased during the course of a lingering illness, and which in itself had no causal relations to the death—the doctor may be prone to certify the death as from the illness alone, taking no note of the accident; and pressure may be brought to bear upon him by the relations of the deceased to so certify and save them the trouble and publicity of an inquest. It should be remembered, however, that although the certificate be accepted by the registrar, and interment take place, the coroner, if informed of the matter, may order the body to be exhumed for the purposes of inquest.

There are coroners who, on receipt of information of death from uncertain causes, may elect, on evidence obtained apart from the medical practitioner, to notify the registrar authorising the interment without holding an inquest. The law, however, states that, "except upon holding an inquest, no order, warrant, or other document for the burial of the body shall be given by the coroner" (50 and 51 Vict.).

The Coroners Act (50 and 51 Vict.) provides that, when a coroner is informed that the dead body is lying within his jurisdiction, and there is reasonable cause to suspect that such person has died a violent or unnatural death, or a sudden death, of which the cause is unknown, or died in prison, he shall summon a jury of not less than twelve, nor more than twenty-three, men to inquire touching the death of such person aforesaid.

If the deceased was attended at his death, or during his last illness, by a legally qualified medical practitioner, the coroner may summon such practitioner as a witness. If the deceased was not so attended in his last illness, the coroner may summon any legally qualified medical practitioner in actual practice, in or near the place where the death happened, to give evidence as to the cause of death. In either case the coroner may require the medical witness to make a *post-mortem* examination

of the body, with or without analysis of the contents of the stomach or intestines.

Should a statement on oath be made by any one before the coroner, that in his belief the death of the deceased was caused partly or entirely by the improper or negligent treatment of a medical practitioner, such medical practitioner shall not make or assist at the *post-mortem* examination.

If a majority of the jury are not satisfied with the medical evidence, they may require the coroner, in writing, to summon another legally qualified practitioner, named by them, to make a *post-mortem* examination, with or without analysis of the contents of the stomach and intestines, and give evidence as to the cause of death. A medical practitioner who fails to obey the summons of a coroner, issued in pursuance of the Coroners Act, is liable to a penalty not exceeding five pounds, unless he shows good and sufficient cause for not having so done. When evidence has been given before a coroner or magistrate, and the case is afterwards sent for trial, copies of the medical report and depositions are given to the judge and counsel, so that evidence given at the trial is compared in detail with that given before the coroner or magistrate. In view of this, it is imperative on the part of medical witnesses to carefully consider their evidence before giving it.

The object of a coroner's inquest is to ascertain whether the death of the person, over whose body the inquest is held, was due to natural causes or not.

The proceedings are not directed against any one, they do not constitute a trial, and hearsay evidence is admissible. The coroner and jury alone have the right to interrogate the witnesses. Counsel may be present in the interest of persons concerned with the inquest who may desire such assistance, but counsel may not cross-examine any witnesses, and may only question them by permission of and subject to the decision of the coroner.

Witnesses are examined on oath, their evidence is taken down, and should the case be transferred to a superior court, they are bound under a penalty to appear and give evidence. The coroner may adjourn an inquest for the purpose of obtaining further evidence, if he should deem it necessary.

Should the verdict of the jury charge a person with murder, the coroner issues a warrant for the arrest of the person, unless

the person be already in custody. In the case of manslaughter the coroner may accept bail. According to the Act 4 Edw. I. c. 2, the coroner and jurors must *view* the body, this being *absolutely necessary* to give jurisdiction to him, and he has the power, within a convenient time after the death, to order a dead body to be disinterred for this purpose.

ORDER OF SUMMONS FROM THE CORONER TO A LEGALLY QUALIFIED MEDICAL PRACTITIONER.

"London.

To wit *To* Esq., Surgeon.

"SIR—By virtue of this my Order as one of His Majesty's Coroners for the *County of London* you are hereby required to be and appear before me and the jury on ......day, the ....day of ....at......o'clock in the..........noon, at.......in the Parish of.................,then and there to give evidence on His Majesty's behalf touching the death of........ , and to make or assist in making a *post-mortem* examination of the Viscera of the Head, Chest, and Abdomen of the body of the said...............with............an analysis and report thereon at the said Inquest. And herein fail not at your peril.

Dated the.............day of.............190 ."

(Signature of Coroner.)

Prosecution.—There was no Public Prosecutor in England until some years ago, when an Act was passed authorising the appointment of such an official, who should undertake the duty of prosecuting in certain and specific cases of public importance, and in districts where the appointment might be agreed upon. In ordinary circumstances it has usually been left to the person against whom a crime has been committed to prosecute the offender.

Magistrates' Court.—In the Magistrates' Court of Petty Sessions, the proceedings are for the purpose of investigating as to the culpability or non-culpability of a person accused of some criminal act, or criminal negligence.

In this Court the accused person must be present, as the inquiry is relative to his guilt or innocence. Witnesses in this Court may be examined and cross-examined by counsel. A magisterial investigation cannot take place if no arrest has

been made. The magistrate may deal summarily with cases of simple assault and such-like of minor import, but when the case is of a more serious nature, and in suspected manslaughter or murder, the accused person is committed to a superior Court for trial, all witnesses, medical or lay, being bound over to appear and give evidence. The summons to the Assizes is called a *subpœna*, and all witnesses receiving the same, when accompanied with reasonable travelling expenses, are bound to obey it.

Assizes.—The Assizes comprise two Courts, the Crown Court and the Civil Court. A separate judge presides over each. In the former only cases of a criminal nature are tried; in the latter suits are tried between two parties. Medical practitioners may be called upon to give evidence in either Court, according to the nature of the case in which they are directly concerned.

Prior to a case being investigated by a judge and petty jury, it has to come before the grand jury. This jury decides whether the case is a proper one to proceed to trial.

The grand jury hear the evidence of such witnesses as they think fit, apart from counsel. Should the grand jury consider the case one for trial, they return a "true bill," and it goes before the judge and petty jury; if not, they "cut the bill," and the accused is discharged.

Medical witnesses may be called upon, when under subpœna, to give evidence before the grand jury.

The Crown Court of Assize consists of a judge and a sworn jury of twelve men, called the petty jury. The latter hear the evidence of witnesses, and are guided by the summing up of the judge. They deliver a verdict after consideration of the evidence, by which the accused person is found guilty or not guilty. The judge, after receiving the verdict, allots such punishment as he considers just.

In the Assize Courts only barristers can plead; in the Magistrates' Courts of Petty Sessions, solicitors or barristers may plead.

In the Courts of Assize the witnesses are subject to the following routine of examination. First, *Examination in chief:* this the witness undergoes at the hands of the barrister who is pleading on behalf of the party by whom the witness is called. In this examination such questions are put to the

witness as may elicit answers conveying to the judge and jury a clear account of all the witness knows with regard to the case. After the examination in chief, the counsel of the opposite side subjects the witness to *cross-examination*, in such a way as to shake the evidence given by the witness during his examination in chief in points which would weigh against the prospects of his client. *It is during cross-examination that a medical witness may be subjected to questions which suggest answers capable of a different interpretation from those he had previously given.* After cross-examination, the counsel for the party upon whose side the witness appears subjects the latter to *re-examination*, if he consider it necessary, during which he endeavours to clear up any doubtful points in the evidence given by the witness during cross-examination, with the purpose of eliciting an explanation of their meaning.

The judge and members of the jury may put such questions to the witness as they may consider necessary.

The same method of procedure applies to the higher Courts.

SCOTLAND.

In Scotland public prosecutors are appointed by the Crown. The chief public prosecutor is the Lord-Advocate; next in rank come the Deputy-Advocates and Procurator-Fiscal. The Lord-Advocate and Deputies take charge of cases in the High Courts of Justiciary, the Procurator-Fiscal in the lower Courts.

The duties of the public prosecutor are to bring all accused persons to a bar of justice; and in addition he acts as the coroner does in England. Any person who is supposed to know anything about the case is interrogated by the Procurator-Fiscal, or is *precognosced*. The examination is made on oath; the written evidence constitutes the *precognitions*. Counsel for the accused or for the Crown may precognosce witnesses.

The preliminary examination of the accused takes place before the Sheriff or Justice, and he may commit the person for trial or liberate him, according to the evidence.

The precognitions, in cases of committal, are forwarded to the Crown Counsel in Edinburgh, who may stop the proceedings, or send the accused before the High Court, Circuit Court

of Justiciary, or Sheriff, with or without a jury. The Justiciary Courts correspond to the Courts of Assize in England. Should the case be so transferred for trial, the witnesses are summoned by writ. A penalty of £5 may be imposed for disobedience to such writ, or imprisonment pending expression of regret before the Court, and tendering bail for appearance.

Common witnesses and medical witnesses to fact are not allowed in Court except when giving evidence. Expert witnesses may be allowed to remain in Court by mutual consent of counsel. When one expert witness is giving evidence, other experts are required to leave the Court, and no expert witness who may have been present during the examination of common witnesses is allowed to give evidence as to facts.

The verdicts of "Guilty" or "Not guilty" are similar to those given in England, but in addition a verdict of "Not proven" may be given, and all are final. In the case of the last two the accused cannot be tried again.

In Scotland the verdict of a bare majority of the jury holds good, whereas in England the decision must be unanimous. In the case of a suspicious death, or a dead body being discovered, the Procurator-Fiscal, acting as a coroner does in England, but without a jury, may direct a medical man to examine the body and send in a report; but all reports must be certified *on soul and conscience*, without which they are of no value. Should the medical examiner be satisfied without making an internal examination, he may certify to the Procurator-Fiscal on the result of his external examination.

Should the Procurator-Fiscal consider it requisite to have a complete examination, he issues a warrant to that effect to the medical practitioner who has seen the case, and usually associates with him the most skilled practitioner available in the neighbourhood. The warrant consists of a petition by the Procurator-Fiscal, addressed to the local judge, setting forth the grounds of his application, and craving warrant to the inspectors named to make the necessary examination. This is signed by the Procurator-Fiscal, and countersigned by the Sheriff or local judge, if granted. The receivers of this warrant are empowered to take full custody of the body, and they should be *careful to carry the warrant with them*, or they may be refused admission pending its production, which may result

in great waste of time, and end in a miscarriage of justice. The Procurator-Fiscal may supply to the medical inspectors portions of the precognitions likely to bear on the medical part of the inquiry. Medical men ought to be on their guard against performing dissections in cases evidently judicial without previously warning the proper law authorities, or without a warrant; for instances have occurred where, owing to the want of proper support, obstructions were thrown in the way which might have proved fatal to the value of the investigation; and, besides, the premature disclosure of the results of the inspection might frustrate other important steps of the precognition.

The medical men so engaged will, as a rule, find it to their interest to exclude all visitors, whether lay or professional, from the room during the dissection. The regulations issued by the Crown Office, Edinburgh, direct that no one should be allowed to be present at the examination out of mere curiosity, and recommend that any one not engaged in the inspection, but who is in attendance to give information, or for any other purpose, and who may afterwards become a witness, should remain in an adjoining room. The medical inspection often furnishes good tests of the value of other evidence in the case; therefore, it is desirable that the general witnesses should not have an opportunity of knowing what is observed in the dissection of the body. The notes of a case should be made at the time of inspection or immediately afterwards. In the case of *post-mortem* examinations it is better that while one inspector conducts the practical details of the examination, the other should take notes of its successive steps, indicating all the points inquired into, with the observations made, the appearances presented, negative as well as positive, stating simple facts alone, without either generalisations or opinions. These notes should be looked over by both inspectors before the body is sewn up, so that omissions in the notes, or in the inspection itself, may be then supplied.

Citation of Witnesses—Subpœna.

In England, except upon a subpœna, a medical man *is not* bound to attend as a witness at a trial, and then it should be served a reasonable time before the trial, in order that he may make proper arrangements for the carrying on of his business

during his absence. In civil cases his reasonable expenses should be tendered to him at the time the subpœna is served, or within a reasonable time of the trial; and he may refuse to give evidence unless his charges are paid, provided his objection be stated *before he has been sworn.* A witness may be summoned from any part of the United Kingdom.

In the United States, the attendance of a medical man, although compulsory in criminal cases, does not entitle him to any fee, whether cited on either side.

The question has been raised, whether a *scientific witness* was bound to attend when subpœnaed. The law on the point is enveloped in some obscurity; the better course is therefore to attend.

No tender of fees is necessary in criminal cases, "except in the case of witnesses living in one distinct part of the United Kingdom being required to attend subpœnas directing their attendance in another, who are not liable to punishment for disobedience of the process, unless at the time of service a reasonable and sufficient sum of money, to defray their expenses in coming, attending, and returning, have been tendered to them." When summoned to two cases, the one civil, the other criminal, the witness must attend the criminal; or when both cases are the same, the one to which he first received the subpœna—notifying, however, to the counsel engaged on the other case his unavoidable absence, and giving the reasons which prevent his attendance.

In Scotland, witnesses are summoned by a writ or citation, which must be delivered at the residence of the witness a reasonable time before the trial. Delivery to a member of the family, or a servant not within the house, will not do. If access cannot be gained, the copy is fastened to the most patent door of the house. If the witness does not appear, and it be clearly shown that he was duly cited, a warrant for his apprehension may be issued, and he becomes liable to be incarcerated till he finds "caution" for his due attendance at the trial. His non-attendance may also, unless good excuse be forthcoming, render him liable to a fine, or *unlaw*, of a hundred merks Scots—about £5.

Form of Subpœna in England.—Where a medical witness has given evidence in a case in which the accused person has been committed for trial to a superior Court, he is summoned to give evidence at such Court in the following terms:—

"Edward, by the grace of God, of the United Kingdom of Great Britain and Ireland, King, Defender of the Faith. To

Greeting: We command you, and every of you, that all business being laid aside, and all excuses ceasing, you do in your proper persons appear before our Court of Quarter Sessions of the Peace [or other Court], assigned to keep the

L.S.

peace in the City (or Borough) of ...., and also to hear and determine divers Felonies, Trespasses, and other Misdemeanours in our said City (or Borough) committed, to be holden within the ...., in the said City (or Borough), on .... the .... day of now next ensuing, at the hour of Ten o'clock in the forenoon of the same day, to testify the truth and give evidence, on our behalf, against .... in a case of ....;
and this and every of you are in no wise to omit, under the Penalty of Twenty Pounds for you and every of you. Witness, , Esq., our Recorder at aforesaid, the .... day of .... in the year of our reign.

"(Signed)

"Clerk of the Peace."

In **Scotland** the following is the form of summons to appear before the High Court of Justiciary, and at an inquiry into a fatal accident:—

(I.)

"*To*

"You are hereby lawfully cited to attend a sitting of the High Court of Justiciary within the Criminal Court ...., upon the .... day of .... Nineteen hundred .... years, at .... o'clock .... noon, as a witness in the case against ...., prisoner in the Prison of , and that under the pain of One Hundred Merks Scots.

"(Signed)

"Sheriff-Officer.

"*Note.*—Any witness failing to appear in terms of citation not only forfeits the penalty, but is liable to be apprehended and imprisoned.

"(Preserve and bring this Copy with you.)"

FEES ALLOWED TO MEDICAL WITNESSES.

Coroner's Court.—The Coroners Act states that fees for medical witnesses attending an inquest shall be, for attending to give evidence at an inquest whereat no *post-mortem* examination has been made by the witness, one guinea. For making a *post-mortem* examination and attending to give evidence, two guineas. No fee can be obtained for making a *post-mortem* examination by a medical practitioner, unless it be made by order of the coroner. Extra fees are not provided for when the inquest is adjourned. For an inquest held over the body of a person who has died in a lunatic asylum, public hospital, infirmary, workhouse infirmary, or other medical institution, whether endowed or supported by voluntary contributions, the medical officer of such institution shall not be entitled to a fee. Should the dead body of a person be taken to such an institution, the medical officer, if summoned to give evidence, is entitled to the usual fee. Such fees are paid at the termination of the inquest.

Magistrates' Court.—If the witness resides within three miles of the Court, the fee is ten shillings and sixpence ; beyond three miles, one guinea.

Assize Court.—One guinea per day, with two shillings a night away from home, and second-class railway fare. If there be no railway, threepence a mile each way. Sundays are not included.

Court of Probate and Divorce. One guinea per day within five miles of the General Post Office. If beyond, two or three guineas a day, with expenses out of pocket for coming and returning.

Court of Appeal.—One guinea a day if resident in London ; two or three guineas, with travelling expenses, if from a distance.

In Civil Cases.—An arrangement is usually made with the solicitor for a fee ; this should be made before accepting the subpœna. A written undertaking for payment, and properly stamped, should be obtained from the solicitor before giving evidence ; in default of this, the witness should appeal to the judge from the witness-box before being sworn. After taking the oath a witness is bound to give evidence, and the solicitor may refer him to his client for the fee, which may lead to disappointment.

IN SCOTLAND.

The fee for attendance at High Courts of Justiciary or the Sheriff Criminal Court is one guinea per day, if the Court is held in the town in which the medical witness lives. For a *post-mortem* examination and report, two guineas. For an analysis of blood or other stains on clothing, two to four guineas, depending upon the amount of work done.

If the witness comes from a distance, he is allowed two guineas per day, both for the actual attendance at Court and also for each day occupied in travelling to and fro, with a guinea a day for travelling expenses.

CHAPTER II.

MEDICAL EVIDENCE GENERALLY.

On the subject of evidence it is necessary to say a few words, for it must be remembered that that which may be held to be evidence in logic may not be so in law. Nothing in law is intuitive—nothing is self-evident; everything must go through the process of proof by testimony.

Legal evidence is therefore composed of testimony, but all testimony is not necessarily evidence in law. Thus, if a witness declare that he saw a certain act committed, his testimony may be accepted as evidence; but if he state that his knowledge of a fact is obtained from another person, such information, although it contain an absolutely true description of what actually occurred, will not be received. In this case his testimony is simply hearsay, and as such is not admissible, except in the case of dying declarations, and in one or two other instances which do not, however, concern us.

Medical evidence may be divided under the following heads:—(1) Documentary; (2) Oral or Parol; (3) Experimental.

1. DOCUMENTARY.

Under this head are included Medical Certificates, Written Opinions, Medical Reports, and Dying Declarations.

The Medical Certificates.—Certificates generally refer to death, to vaccination, to the state of health of an individual, etc. For those which have respect to the health or to the illness of an individual there is no particular legal form, as a certificate is merely a simple statement of a fact. The only essential condition is that it contains the exact truth, and any departure from this will entail heavy penalties. The laxity

and want of care in giving certificates was sadly exemplified in a recent trial,—Mr. Justice Hawkins remarking that he was "determined never to accept a doctor's certificate again unless it is accompanied with the affidavit of the doctor." The offending medical man has certainly not added to the credit or honour of his profession. A statement signed by a registered medical practitioner, distinctly describing the condition of A or B, is all that is necessary as far as the law in England is concerned. In Scotland the law is somewhat different, for "A certificate of bad health by a physician or surgeon must bear to be *on soul and conscience*." . . . "In cases of homicide, and other crimes against the person, medical certificates produced respecting the nature of the injuries must be verified on oath by the medical persons who granted them" (*Dictionary Scot. Law*). In Scotland also, the omission of the words "on soul and conscience" invalidates a certificate, and a juryman suffering from illness has been fined because the words were omitted in the medical certificate on which he claimed exemption.

Certificates of death, of vaccination, and of insanity can be procured already printed in the forms prescribed by the law.

Written Opinions.—These generally refer to civil questions.

The Medical Report.—A *Report* is a document given in obedience to a demand by the public authorities in Scotland, and has reference chiefly to criminal cases. Medical Reports are sworn to as true by those who draw them up. According to Alison, it is not a sufficient objection that a Medical Report was made up at an interval after the occurrence of the circumstances to which it refers. The same high authority also states that should the writer of a Medical Report die before the trial, his Report may be used in evidence,—this may be doubted.

The necessity for simplicity in the arrangement and in the wording of their Reports cannot be too strongly urged on medical men. "A medical witness will do well to remember, also, that copies of his Report and depositions, either before a coroner or a magistrate, are usually placed in the hands of counsel as well as of the Court; and that his evidence, as it is given at the trial, is compared word for word with that which has already been put on record." All hearsay statements and irrelevant matter should not be inserted in a Report; and the reporter should be particularly careful not to add any

comments to his simple narration of facts. Thus, such expressions as these—"Under circumstances of great suspicion," "That this woman was murdered, and that with extreme ferocity," "That a severe struggle had taken place before death"—were severely commented on by the late Lord Deas in the case of R. *v.* M'Lachlan. The use of superlatives is also very objectionable, as it partakes somewhat of exaggeration. All technical words or phrases should be as much as possible avoided; and where they are absolutely necessary, they should be briefly explained.

As a case in point, showing the necessity for care in the use of words, I quote the following from a published Paper by the late Sir R. Christison:—"Some years ago, on an important trial in the High Court of Justiciary for assault, the public prosecutor attempted to prove that the person assailed had been wounded to the effusion of blood; which is held in law to be an aggravation of guilt in such cases. When the principal medical witness was examined as to the injuries inflicted, he was asked whether any blood had been effused; and he replied that a good deal must have been effused. But he meant that there was effusion of blood under the skin, constituting the contusion he had described; while the counsel and the Court at first received his answer as implying that there had been considerable loss of blood from a wound. The latter view was on the point of passing to the jury as a fact, when one of the judges detected the equivoque, and set the matter to rights."[1]

In Scotland a medical practitioner may be called upon by the authorities to grant reports as to dead bodies, without performing a *post-mortem* examination.

In the first case, where a death has occurred unaccompanied by any suspicious circumstances, or where the evidence of suicide or death from accidental injury is apparent from a simple examination of the body, a certificate "on soul and conscience," stating the probable cause of death, is considered sufficient by the authorities, and a *post-mortem* is dispensed with. It is not necessary that the deceased be seen by the medical practitioner before death, "yet, from the suddenness of the death, the age of the deceased, and the symptoms spoken to by the friends, he may still be enabled, satisfactorily to

[1] *Monthly Journal of Medical Science*, 1851.

himself, to certify the cause of death." In England, such a case would be the subject of a coroner's inquest.

In the second case, he may be summoned by a constable to inspect a body found on the public road, or in any other unusual situation. In this case he is called not only to certify the fact, but also the probable *cause* of death. He may, under these circumstances, give a report of the external examination of the body, at the same time suggesting the necessity for further and more careful examination by dissection, etc., and this we consider the proper course for him to take. In England, in this case also, an inquest would be necessary. In all cases medical men will consult their own interests in giving these Reports.

A Medical Report consists of two parts—the *Minute of the Examination*, and the *Reasoned Opinion* on the first portion of the Report. In the case where the Report is made by two or more persons appointed for the purpose, the latter portion is written in the plural, and signed by each of the parties certifying.

The following is an outline of a Medical Report, which may be more or less modified to suit the requirements of the case:—

FORM OF MEDICAL REPORT.

(*Date.*) (*Place of Examination.*)

(*Names of those who can speak to the Identity of the Body.*)

I. MINUTE OF THE EXAMINATION.

1. External Inspection.

1. General Condition of the Body.—*(a) Well or ill nourished. (b) General colour. (c) Marks and scars. (d) Products of disease—Ulcers, hernia, etc. (e) Injuries.*

   Caution.—There may be no external marks of injury, and yet death may be due to violence. Extreme difficulty in deciding if injury be inflicted before or after death.

2. Height.—*Determined by measurement.*
3. Age.—*This can only be approximately guessed.*
4. Sex.—*This is, of course, only difficult when putrefaction is far advanced. Hair found only on the* mons veneris *or* pubes *is characteristic of the female, but if it extends upwards on the abdomen, equally so of the male. No sex can be distinguished in the embryo before the third month of intra-uterine life.*
5. Colour of the Eyes.—*Difficult of determination.* Why? *(a) Disagreement of observers. (b) Presence of putrefaction.*

6. Colour of the Hair.—*This is necessary, in order to compare hair of deceased with that found on suspected party.*
7. Position of the Tongue.—*Normal or abnormal, injured or uninjured.*
8. Condition and Number of the Teeth.—(*a*) *Complete.* (*b*) *Incomplete.* (*c*) *Any peculiarity as regards size or form, in order to compare with mark or bite on suspected party, etc.*
9. Signs of Death.—*Presence or absence of the* rigor mortis *or supervening putrefaction.*
10. Condition and Contents of the Hands and Nails.—(*a*) *In the drowned: weeds, sand, and signs of long immersion.* (*b*) *In those shot: scorching or blackening of the hand from powder, or injury from recoil of the weapon. Is the weapon grasped firmly in the hand? Cadaveric spasm? Cadaveric rigidity?*
11. Condition of the Natural Openings of the Body—Nose, Mouth, etc.—(*a*) *Presence of sand or weeds in mouth of those found in the water.* (*b*) *Presence of marks of corrosive poisons.* (*c*) *Presence or absence of the signs of virginity, or of recent injury about the parts.*
12. Condition of the Neck.—(*a*) *Presence of marks of strangulation.* (*b*) *Condition of the upper cervical vertebræ.* (*b*) *Dangers to be avoided in determining the fracture or dislocation of the cervical vertebræ. Great mobility of neck, sometimes present, not due to injury of the bone.*

2. Internal Inspection.

A. Cranial Cavity.

1. Condition of the bones of the skull.
2. Condition of the membranes and sinuses of the brain.
3. Condition and appearance of the brain substance.
4. Contents of the lateral ventricles.

B. Thoracic Cavity.

1. Position of the organs on opening the chest.
2. Condition of the heart, large blood-vessels, and pericardium.
3. Condition of the lungs, larynx, trachea, and gullet.

C. Abdominal Cavity.

1. Position of the abdominal organs.
2. Healthy or diseased condition of the liver, spleen, stomach, bladder, and kidneys.
3. Contents of the stomach and bladder.—*Should it be necessary to remove the stomach and intestines, a ligature should be placed at the cardiac extremity of the stomach, and another on the sigmoid flexure of the colon, and then a division beyond the ligatures will permit of the entire removal of the bowels.*
4. Condition of the blood-vessels.
5. Condition of bones and joints.

II. THE REASONED OPINION.

In this portion of the Report the inspectors state the nature of the conclusion at which they have arrived, and their reasons.

Recapitulation of the foregoing Rules.—It may be of advantage here to re-state, in a tabular form, a few suggestions as to the composition of the Report:—

N.B.—1. Let the Report be as short as possible, but state your views with clearness and distinctness. After stating the nature of the disease in any organ, report "all other organs healthy," if they have been found so. To specify some organs, omitting others, may lead to a puzzling inquiry from counsel as to the condition of the suprarenal capsules, or some other unimportant organ, and an unfounded doubt cast on the Report of the examiner.

2. Always avoid the use of technical terms as far as possible, so that you may be saved the annoyance of having to explain your meaning in the witness-box.

3. Express all dates and numbers in writing. Measure all marks, and describe their size and appearance in writing. Carefully write all names of persons to whom reference is made. Take accurate notes, and from them compose your Report. Make a list of all articles submitted for inspection and analysis, and label them.

4. State all facts clearly and chronologically. *A fact* is what is known directly and personally to witness, and not what has been reported by some other person. Do not report hearsay testimony as matters of fact.

5. Every Report should be written under the impression that it may come into Court to be read.

6. Always avoid superlatives and all epithets of feeling or impressions on the mind.

7. Always avoid speculative opinions and reference to moral circumstances, unless specially required to do so.

8. State your conclusions at the end of the Report in as few sentences as possible.

9. Keep a rough draft of all your Reports, for future reference.

10. Transmit Report, signed and dated, without unnecessary delay, to proper authorities.

Dying Declarations.—The principle on which these are accepted is founded partly on the awful situation of the dying person, and partly on the absence of interested motives in one on the brink of a terrible eternity, and which is supposed to obviate the necessity of a cross-examination. Unfortunately the annals of criminal jurisprudence are not free from lamentable instances of the hollowness of the above assumptions,—see the dying instructions of David to his son Solomon, and the writings of Mr. Amos and others on the subject. The greatest care must be taken by the medical man who is called in to see a person supposed to be dying, with regard to any declaration he or she may wish to make. The medical attendant should simply take the statement as it is made, writing it down on the

spot, or as soon after as possible. The identical words used should be committed to paper, and no suggestions or interpretations of his should be made. Leading questions should *never* be put, nor any attempt made to induce the patient to make any statement. When we consider the condition of the patient, the possibility of delirium induced by the severity of the injury, together with the dread of death, it is, to say the least, injudicious to introduce the suspected party into the room for the purpose of identification, though this procedure has been suggested by some writers. In every case, however, it is advisable for the medical attendant, as soon as he sees that the case must end fatally, to acquaint the patient in the presence of others of the fact, when any statements made may then be taken. It is preferable that such statements be made before a magistrate if time will allow. It should also be borne in mind by those receiving dying declarations, that in England "it must be shown that the deceased, at the time he made the statement, was under the impression that death was impending; not merely that he had received an injury from which death must ensue, but that, as the popular phrase goes, 'he then believed he was on the point of death'" (R. *v.* Forester). In one case (R. *v.* Fagent, 7 C. & P. 238) it was held that a declaration was inadmissible, because the person making it asked some one near her whether he thought she would "rise again"; and it was held that this showed such a hope of recovery as rendered the previous declaration inadmissible. The declaration should be signed by the person making it, and witnessed by some one present at the time.

In the case of Reg. *v.* Whitmarsh (Central Criminal Court, Sept. 19, 20, 21, 1896), 62 J.P. 680. Upon an indictment for the murder of a woman, who died as the result of the prisoner having used certain instruments or other means upon her with the intent to procure her miscarriage, it was shown that an inspector of police had seen her at Charing Cross Hospital. He asked her questions, and from her answers he wrote down a statement. The woman signed it. On July 7 the woman appeared to be in a dying condition, and was aware of it. She said she feared she must die, and asked to see her mother and a clergyman. The doctor told her that he had given up all hope, and that she might not live to see her mother. A magistrate saw her shortly afterwards, and read over to her the statement she

made on June 29, and he affixed to it the following note, "This statement was read over to Alice Bayley by me, and is referred to in her dying declaration," and signed. *Held* (Darling J.), that though this statement might be admissible, it had better not be admitted in evidence. On the same day the woman had also made a statement to the magistrate, of which he had taken note, but before it was finished, she became exhausted. The magistrate then took the statement of June 29, repeated portions of it to her in his own words, wrote these down, and asked her if it was correct. He then read the whole statement to her and she signed it. The statement commenced, "Having the fear of death before me, and being without hope of recovery"—concluding with the words, "And the statement I made on the 29th of June, and have now heard read over, is true."

Justice Darling held this statement was admissible as a dying declaration.

In the case of Rex *v.* Smith, 65 J.P. 426 (Bruce J., Central Criminal Court). A magistrate and a doctor visited a dying woman for the purpose of taking her statement. In reply to a question put to her by one of them, she said, "I am aware that I am seriously ill." The magistrate asked her questions and the doctor wrote down the answers. At the trial the statement was objected to as inadmissible as a dying declaration on two grounds: Firstly, that the statement consists only of answers to questions put to her by the magistrate, and so comes within the ruling of Cave J. in Reg. *v.* Mitchell, 17 Cox C.C. 503, that "a declaration should be taken down in the exact words which the person who makes it uses, in order that it may be possible from those words to arrive precisely at what the person meant. When a statement is not the *ipsissima verba* of the person making it, but is composed of a mixture of questions and answers, there are several objections open to its reception in evidence. . . . In the first place, the questions may be leading questions, and in the condition of a person making a dying declaration there is always very great danger of leading questions being answered without their force and effect being fully comprehended."

Secondly, the prosecution had not shown that at the time the woman made the statement she was in expectation of immediate death.

The judge held (1) That the prosecution had not proved

that in her own opinion the woman was beyond all hope of recovery, and that therefore the statement was inadmissible; (2) That such a statement—the magistrate asking her questions and the doctor taking down only her answers in writing—was not admissible as a dying declaration.

In the case of Rex *v.* Holloway, 65 J.P. 712 (Wills J., Central Criminal Court). The prisoner threw a burning lamp at his stepson and set fire to his stepdaughter, who succumbed to the burns she received. A deposition of the deceased girl was taken down by a magistrate. At the time it was taken it was intended that it should be in accordance with the provisions of the 1867 Act. The accused was present and had full opportunity of cross-examining the witness. The deposition was read over to the girl, and she assented to it, but could not sign it because of the injuries to her hands. The magistrate who took the deposition signed it. It was held that the deposition had been taken in accordance with the provisions of the Indictable Offences Act, 1848, sec. 17, and was admissible though it had not been signed by the girl.

The validity of a dying declaration has been called in question when made by a person who has suffered a severe concussion of the brain, and then recovered his sensibility. It is well known that under such circumstances the recollection of what took place before or after the injury is in many cases very imperfect, and the injured party may thus draw unintentionally upon his imagination for his facts. In Scotland, "the written deposition of a person who is dead is admissible, whether the person were the party injured or not, if he would have been a competent witness. It is not necessary that the deceased believe himself to be dying when he emits the deposition, for his consciousness of approaching death may be inferred from the nature of the wound, or the state of illness or other circumstances of the case. Such depositions are generally taken by a magistrate, but a declaration deliberately made, though without an oath, and taken down 'by a creditable person,' is admissible" (Macdonald, *Scottish Criminal Law*, p. 512).

2. ORAL OR PAROL.

A medical man may be called as a *common* witness, or as an *expert* or skilled witness. In the *first* case, he has only to

state, as any other witness might do, the facts that have fallen under his observation; in the *second*, he has to interpret the facts he has himself observed, or to give his opinion on facts noticed by others. In stating his opinion, a medical witness must be prepared to back up his opinion by such reasons as may be satisfactory to the understanding of his hearers, "and this is the principal qualification of a medical witness, that he make himself *intelligible to ordinary comprehensions*." No man is bound to give any testimony by which he may render himself liable to any criminal prosecution. (See the ruling of Bailie J. in the case of Mr. George Patmore, tried for the murder of John Scott in a duel.)

At the trial, the witness is first examined by the party who calls him: this is the examination-in-chief. He is then cross-examined by the opposite party; and, lastly, re-examined by the former party, when he is offered the privilege of explaining any discrepancies between his examination-in-chief and cross-examination, but he must not introduce any new matter, for by so doing he renders himself liable to be cross-examined on it.

The Use of Notes.—All notes should contain a plain statement of the facts, and, to render them admissible as evidence, they must be taken *at the time*, and duly attested. From the notes prepared as before mentioned a witness may refresh his memory, but they are not accepted in its place. A witness may not read his notes as evidence, nor may he refresh his memory by documents not his own and not produced, but he may refresh his memory by looking at a document received from the accused at the time of the offence, and kept by him (Geo. Wilson, jun., Aberdeen, May 1, 1861; 4 Irv. 42).

The Use of Books.—No witness is allowed to quote from books, or to quote the opinion of other medical men on the subject, but he may refer to facts. Sir Henry Littlejohn, in his papers on Medical Jurisprudence,[1] gives some useful hints on this subject. It appears that a medical witness, in an unguarded moment, stated that his opinion was corroborated by a distinguished member of the medical profession not engaged on the trial. The judge informed the witness that it was most irregular to have other medical men present at the dissection than those mentioned in the warrant, and that, if the

[1] *Edinburgh Medical Journal*, February 1876.

witness did not feel qualified for conducting such dissections, he had better resign the post of medical inspector.

In England, at the request of both parties, the medical and scientific witnesses may be excluded from the Court, but as a general rule they are allowed to be in Court and hear the whole of the evidence of the case. In Scotland they are always excluded, although, by mutual consent, "experts" may remain to hear the general evidence on which they are to express their opinions, but when an expert is giving his opinion the others must leave the Court. In the latter country also, a medical witness who has been in Court cannot be examined on the facts of the case, but only on matters of opinion. A medical man is, however, sometimes allowed, on a special motion, to remain, although he is to be examined as to facts, and withdrawn when other witnesses are to be examined as to facts to which he is to speak. (See case of E. W. Pritchard, H. C. 1865; 5 Irv. 88.)

In giving evidence the witness should—(1) Speak loudly and distinctly. (2) Answer questions categorically—Yes or no. (3) Never use superlatives. (4) Give answers irrespective of results of trial. (5) Express no opinion as to guilt of prisoner: state facts only. (6) Avoid using technical terms. (7) Avoid long discussions, especially theoretical arguments.

When a quotation is made from a book by the examining counsel, the medical witness, before replying to a question based on it, should see that the quotation has been fairly and fully given, due regard being paid to the context. Neglect of this precaution may lead him into considerable difficulty.

A medical witness should remember that he is not retained for a party, but in the cause of justice. He must, therefore, be candid in his manner and simple in his language. Mr. Haslam remarks that, however dexterous a witness may show himself in fencing with the advocate, he should be aware that his evidence ought to impress the judge, and be convincing to the jury. Their belief must be the test by which his scientific opinion is to be established. That which may be deemed by the medical evidence clear and unequivocal, may not hit the sense of the gentlemen of the long robe, nor carry conviction to the jury.

The advice given by Sir W. Blizard may not be out of place here:—"Be the plainest man in the world in a Court of

Justice; never harbour a thought that if you do not appear positive, you must appear little and mean for ever after; many old practitioners have erred in this respect. Give your evidence in as concise, plain, and yet clear manner as possible; be intelligent, candid, open, and just, never aiming at appearing unnecessarily scientific. State all the sources by which you have gained your information. If you can, make your evidence a self-evident truth: thus, though the Court may at the time have too good or too mean an opinion of your judgment, yet they must deem you an honest man. Never, then, be dogmatic, or set yourself up for judge and jury; take no side whatever, be impartial, and you will be honest. In Courts of Judicature you will frequently hear the counsellors complain when a surgeon gives his opinion with any of the least kind of doubt, that he does not speak clearly; but if he is loud and positive, if he is technical and dogmatic, then he is allowed to be clear and right. I am sorry to have to observe that this is too frequently the case."

Liability of Medical Men to reveal Professional Secrets.— The question has arisen how far a medical man is bound to reveal the secrets confided to him in his professional capacity as medical attendant. This question was raised by Mr. Caesar Hawkins in the trial of the Duchess of Kingston (11 Harg. St. Tri. 243), before the House of Peers, and decided by Lord Mansfield thus:—"Mr. Hawkins will understand that it is your (the other Peers) judgment and opinion that a surgeon has no privilege, where it is a material question in a civil or criminal course to know whether parties were married or whether a child was born, to say that his introduction to the parties was in the course of his profession, and in that way he came to the knowledge of it. I take it for granted, that if Mr. Hawkins understands that, it is a satisfaction to him and a clear justification to all the world. If a surgeon was voluntarily to reveal these secrets, to be sure he would be guilty of a breach of honour, and of great indiscretion; but, to give that information in a Court of Justice, which, by the law of the land, he is bound to do, will never be imputed to him as any indiscretion whatever." This is not the ruling in most Continental countries, where the medical man claims the same privileges of secrecy as the priest in confessional.

3. EXPERIMENTAL.

Under this head will be treated the Examination of the Living and the Dead, Identity, Real and Apparent Death, Cause of Death, Exhumations, and Autopsies.

EXAMINATION OF THE LIVING.

With regard to the identification of the living, the presence of a medical man is seldom required, but there are many occasions when his opinion may be sought. Thus, under the Factory Acts, he may have to examine children about whose age doubts may have arisen. The Table on p. 37, giving the periods at which the teeth appear, will assist him. A medical man may also be requested to give an opinion as to the mental soundness or unsoundness of an individual. He may also be consulted in cases where questions have arisen as to the existence and character of certain marks on the body—of deformities, either congenital or produced subsequent to birth, or of doubtful sex. The marks which most frequently give rise to differences of opinion are *nævi materni*, *scars*, and *tattoo marks.* In cases of doubtful sex, the male organs may resemble the female, the female the male, or they may be blended together in about equal proportions.

The following questions may be put to the medical expert—(1) Do scars ever disappear? (2) Can the age of a scar be definitely stated? (3) Can tattooing, when once present, ever become thoroughly effaced by time?

In reply to the first and second questions, I shall quote the words of the late Professor Casper:—"Consequently the scars occasioned by actual loss of substance, or by a wound healed by granulation, never disappear, and are always to be seen upon the body; but the scars of leech bites, or lancet wounds, or of cupping instruments, may disappear after a lapse of time that cannot be more distinctly specified, and may therefore cease to be visible upon the body. It is extremely difficult, or impossible, to give any certain or positive opinion as to the age of a scar."

All cicatrices should be examined with oblique light and the aid of a lens. In the early stages a cicatrix is of a red colour, changes to brown, and later to white, and the surface glistens. In the intermediate stages one could not give any positive

evidence of the age of a cicatrix. The probability is that a red cicatrix is a recent one, a white cicatrix is not recent.

I have seen well-defined cicatrices upon the back of a Russian, after incisions made by the blades of a cupping instrument fourteen years previously, and in an Englishman after twenty-five years (R. J. M. Buchanan).

Devergie states that where the brand of a galley-slave has vanished, it may be recalled by slapping its usual position with the palm of the hand. The scar remains white, while the skin round it is reddened. A change of temperature to the part will sometimes cause the reappearance of a vanished scar. Washing may also help to reproduce scars. Cicatrices produced in childhood may grow in length, but not in breadth. The shape of a cicatrix will depend upon the character of the wound which produced it; on the nature of the healing process; on the elasticity or tension of the skin; on the convexity of the part; and on the looseness of the subcutaneous cellular tissue. An incised wound healing by the "first intention" will most probably leave a white linear cicatrix; on the other hand, a wound healing by granulation will leave a more or less irregular scar. The position of a wound on the body also modifies the subsequent cicatrix; thus a linear cicatrix is produced when the wound is in the long diameter of the limb, a more or less oval one when across the limb. The retraction of the skin in the latter case tends to draw the skin at right angles to the line of incision, thus approximating the extremities of the cut, increasing it in breadth and lessening it in length. Owing to one or more of the above-mentioned conditions the typical cicatrix of an incised wound is elliptical, tending, however, in some cases to assume a circular form. Linear cicatrices are found chiefly between the fingers and toes, and where the cutaneous surfaces are concave. In gunshot wounds the resulting cicatrix is depressed and disc-shaped, and more or less adherent in the centre to the subcutaneous tissues, and if the weapon be fired close to the surface of the body, grains of unburnt powder may be seen in the surrounding skin. Cicatrices from burns are, as a rule, large, irregular, and superficial, and frequently give rise to deformity. A scar left by caustics is circumscribed, deep and depressed in the centre. Cicatrices in the groins are probably syphilitic; those in the neck and under the jaw, strumous.

Dupuytren and Delpech state that the tissue formed in a cicatrix is never converted into true skin—the *rete mucosum* when once destroyed never being re-formed. It contains no sebaceous glands, sweat glands, or hair follicles, and is but slightly vascular. This may account for the white colour of ordinary cicatrices, but even to this rule exceptions may be taken, and dark brown patches of pigment have been known to mark the situation of old lacerated wounds. I have seen a well-defined dark coloration of the skin continue for three months after the application of a mustard plaster, followed at the time by desquamation.

With regard to tattoo marks, the question of their disappearance gave rise to considerable discussion in the celebrated Tichborne case. On this subject the experiments of Hutin, Tardieu, and Casper appear to point to the fact "*that tattoo marks may become perfectly effaced during life*," but that after death the colouring matter with which the marks were made may be found in the lymphatic glands. This is especially the case when vermilion is used. The most permanent marks are made with Indian ink, powdered charcoal, gunpowder, washing blue or ink, and vermilion. These are given in the order of their permanency. Hutin found that in 506 men who had been formerly tattooed, the marks had disappeared from 47 of the number. Not only does permanency depend upon the colouring matter used, but also upon the depth to which it has penetrated. If superficial, it may gradually become effaced. If the material be carried down to the papillæ, it will remain permanent, and can only be removed in such a way as to leave a scar. But besides the spontaneous disappearance of tattoo marks from the lapse of time, these marks may be artificially removed, and in such a manner as to prevent the possibility of a definite opinion being given as to their primary character. The presence of a scar in the situation of a well-known tattoo mark is suspicious. Thus, the Claimant had a scar on a part where it was sworn that Arthur Orton had been tattooed. The alternate application of strong acetic acid, potash, and dilute hydrochloric acid appears to be the means adopted for the removal of tattoo marks. (On this subject see also Tardieu's paper in the *Annales d'Hygiène Publique*, Jan. 1855, pp. 171 *et seq.*)

The presence and characters of birth marks should be noted

for purposes of identification. Their removal may be possible, but, except in such as are small and superficial, the process used for removal leaves traces behind in the form of cicatrices or irregularities of surface, which may generally be detected in oblique light and with the aid of a good lens. Large moles or *nævi* may be excised, but a cicatrix will remain, which will differ in shape from the original mark.

The identity of the accused may be further proved by the absence or malformation of the teeth corresponding with a bite on the party assaulted. Or it may be proved that the wound inflicted could only have been made by a left-handed person, or in a manner peculiar to those engaged in the slaughtering of animals—*e.g.*, is the cut from within outwards, as employed by butchers? The correspondence in the size of the foot of the prisoner and the footprints found in the vicinity of the crime is important as evidence. The size of the footprint varies in running, walking, or standing, and this fact should always be borne in mind when an examination is required to be made of the footprints in the neighbourhood of the crime. Photographs may be used as a means of identification. Casts of footprints may be taken by smearing the print carefully with oil, and pouring in liquid plaster of Paris, or by dusting it over with powdered paraffin wax, and then melting it by holding a hot iron over the print; this may be repeated until a sufficiently thick cast is obtained. Hot solution of gelatine in water, mixed with oxide of zinc and glycerine to the requisite consistence, may be used for the purpose.

As a means of disguise the hair may be dyed, or the colour may be changed from dark to light. For darkening the hair, solutions of permanganate of potash, of the acetate of lead or the nitrate of silver, are most frequently employed, a wash containing the sulphide of potassium being used before the application of the lead solution. This removes the grease, and helps the rapid formation of the black sulphide of lead. To detect this fraud, some of the suspected hair should be steeped in dilute nitric acid, the acid driven off by gentle heat, and the nitrate dissolved in distilled water, and then sulphuretted hydrogen passed through the solution, the result being the formation of the black sulphide of lead. If silver be present, the addition of hydrochloric acid will throw down the insoluble chloride of silver. If careful examination be made of dyed

hair, it will be found that the dye is irregularly taken by the hair, and I have not unfrequently seen the hair close to the scalp white, or at least several shades lighter than the rest. The scalp may also be seen more or less discoloured, especially when the nitrate of silver is used and applied by the individual himself.

For lightening the natural colour, solutions of chlorine and of the peroxide of hydrogen, of varying strengths, are used ;

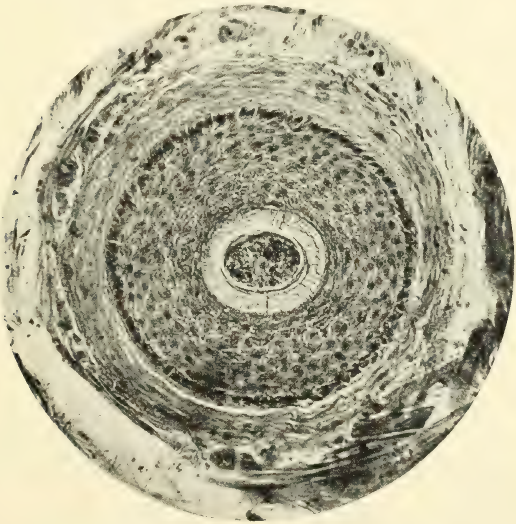

Fig. 1.—Photo-micrograph of transverse section of normal hair follicle, ×250. (R. J. M. Buchanan.)

but it must be remembered that the action of chlorine is by no means uniform. The hair retains the odour of chlorine for some time, even after repeated washing, and is hard, stiff, and brittle. Devergie states that he has not succeeded in producing a perfect whitening of the hair in less than from twelve to twenty hours. It must be borne in mind that, under certain circumstances, dark hair may become suddenly white. I have seen large patches of grey hair over the head, the result of repeated attacks of neuralgia.

There is one more question bearing on this subject, viz.: What amount of light is necessary for the purpose of identification?

In one well-authenticated case, a lady was enabled to identify the person of a thief by the light emitted by a momentary flash of lightning; and it also appears probable that the flash of light from a gun or pistol may be of sufficient intensity for the purposes of identification.

Table giving the diagnosis of the several forms of insensibility that may be present in persons found in the streets:—

Opium or Narcotic Poisoning.—Pupils contracted to a pin point; the countenance placid, pale, and ghastly; eyes heavy; lips livid; skin cold, bathed in profuse perspiration. In some cases may be momentarily roused by a sharp question or blow. Odour of opium in the breath.

Apoplexy.—Patient is with difficulty, if ever, temporarily aroused. Face red and bloated; puffing of the cheeks during respiration. Pupils dilated or irregular. More or less lateral paralysis. Patient short-necked, corpulent, middle or advanced age.

Drunkenness.—Odour of alcohol in the breath—this sign must be received with great caution, for alcohol may have just been taken to ward off "queer sensations." Other signs not unlike those of apoplexy.

Syncope.—Face pale; pulse irregular, flickering, sometimes almost imperceptible; coldness of face and extremities; breathing shallow, scarcely perceptible, irregular sighing or gasping.

Epilepsy.—Unconsciousness profound; then convulsions, unilateral, limited to side of the face, or head and neck, or to the arm. Face distorted; bloody froth round mouth; jaws clenched, sometimes on tongue; eyes wide open, and pupils dilated and insensible to light.

N.B.—Carefully note signs of injury. Could they be caused directly by an assailant or received as the result of a fall.

EXAMINATION OF A PERSON SAID TO HAVE BEEN ASSAULTED.

Carefully examine the bruises, wounds, etc., to see if they could have been inflicted as described. Ask no questions that may suggest an answer. Examine all weapons said to have been used, and hand them over to the police. In all cases where danger to life is imminent, send to the authorities, and take dying declarations, as these may become evidence of vast importance, and, if properly taken, are as valid as if given on oath.

EXAMINATION OF PERSONS FOUND DEAD.

Objects of such Examination.—Under this head the following questions arise: (1) Who is it? (2) What is the cause of death? (3) What period of time has elapsed since death occurred?

1. To answer the question, Who is it?

As an aid to identification, it is important to remember that certain trades leave marks by which those engaged in them may be identified.

Thus, in shoemakers there may be more or less depression of the lower portion of the sternum, due to constant pressure of the last against the bone.

Tailors work sitting, with the legs crossed and the body bent forward. The body is thus cramped, and the abdomen drawn in, and the thorax projects over it, due to the manner of sitting. They frequently have a soft red tumour on the external malleolus. A like tumour, but not so large, may also be found on the external edge of the foot, and a corn on the little toe.

Photographers have their fingers blackened by nitrate of silver, pyrogallic acid and other developers, or stained yellow with bichromate of potash.

Seamstresses have the index finger of the left hand roughened by the constant pricking of the needle.

Copyists have on the little finger of the right hand, near its extremity, a corn, and at the end of the middle finger a hard groove made by the pen.

Violinists have corns on the tips of the fingers of the left hand, harpists on both hands.

In smokers of pipes the incisors and canines are more or less worn by the mouthpiece, but sometimes the groove is between the canines and bicuspids. In cigarette smokers, the forefinger and thumb are stained with tobacco juice, also between the index and middle fingers, on the dorsum.

In coachmen, corns may be formed between the thumb and index finger, and between the index and the second finger of the left hand, from the pressure of the reins, and between the thumb and index finger of the right hand, from the pressure of the whip.

In bricklayers, from the constant action of picking up bricks, the flattening of the tip of the thumb and index finger of the left hand is not uncommon.

Plasterers have corns on the external surfaces of the thumb and index finger, due to grasping the "hawk" on which the plaster is placed during their work.

Joiners and carpenters have callosities on the palm of the right hand from grasping their tools, and between the thumb and index finger of the right hand, also over the first interphalangeal joint of the right index finger. The right shoulder is lower than the left.

The finger-ends of turners and coppersmiths are also more or less flattened; in the latter, a deposit of the metal may take place.

An examination of the mouth, for the presence or absence of false teeth, or of any peculiar formation of the jaw, may lead to the identification of the body. In the case of Dr. Parkman, the recognition by a dentist of the false teeth worn by the deceased led to identification of the remains, and also to the discovery of his murderer. The presence of an ununited fracture, as in the case of Livingstone, may lead to the identification of the body. In one case where a man was said to have died from a fracture of the ribs recently caused by a blow, it was found on examination that the bones were united by a firm callus, clearly showing that the skeleton produced could not be that of the man alleged to have been murdered. *Nævi materni* and cicatrices, as in the case of the living, may also serve as aids for identification; also congenital hare-lip, cleft palate, congenital or other deformities of limbs, supplementary mammæ, artificial indentures, old joint disease or dislocations. Singular cases of mistaken identity have been recorded, from the extraordinary occurrence of like marks on different individuals. In the case of an infant found dead, it may be necessary to determine whether it was born alive, and also whether it had reached that period when it could maintain an existence apart from its mother. (See "Infanticide.")

2. To ascertain the cause or causes of death.

(1) Position of the body.
(2) Attitude of the body.
(3) Relation to surrounding objects.—Signs of a struggle.

Direction of footsteps to or from the body. If in a room: What bottles and other articles of medicine are in the apartment? Examine the nature of the excrementitious matter in the night-vessels.—Suicide? Homicide?

(4) Examine body externally.—Are there any wounds on the body? Are there any signs of vital reaction in the wounds; pus, adhesive lymph, or blood clots? Possibility of apoplexy; conformation of the neck, with respect to its shortness, fulness, and thickness. Marks upon the throat or under the ears. State of the linen and clothes of the deceased. Whether torn or in any way disordered. Whether stained with blood. Whether they yield the odour of spirit, sourness, putridity, or that of tobacco. Leave the examination of the back till after the examination of the internal cavities, so that no fluids escape from mouth, etc.

(5) Report of witnesses.—Can the body be identified? Is the body in the same situation and condition as when first discovered? Habits of the deceased. When last seen, and in whose society? What was his occupation or business? Had he experienced any disappointment or misfortune? Any insurance on his life?

(6) Examine cavities.

In no case should a medical man ever hazard an opinion as to the cause of death. When the body is once placed in the hands of the authorities, a medical man has nothing further to do till he receives the warrant for inspection and examination, without which he should be careful not to touch the body for purposes of internal examination.

3. **To ascertain the time which may have elapsed since death.**—This can scarcely be determined with precision, as so much depends upon the conditions under which the body may have been placed. The subject under consideration is, therefore, beset with difficulties, and its elucidation will require the greatest care on the part of the medical expert. A careful attention, however, to the subjects treated in the following pages will help to clear up many a doubtful point.

COOLING OF THE BODY.

(1) External circumstances.	Covered by bed-clothes, or otherwise unexposed, when cooling will be slower than in cold dry air quickly moving.

(2) Condition of the body itself.	Slow, if fat.	
(3) Kind of death.	1. Wasting diseases. Quick.	
	2. Suffocation. Slow.	
	3. Cholera, yellow fever, rheumatic fever, and cerebro-spinal meningitis.	Increase of heat after death.

The following circumstances must also be taken into consideration :—(1) Age. (2) Air—(*a*) moving ; and (*b*) at rest. (3) Moisture. (4) Warmth. (5) Nature of the supposed cause of death, as affecting cooling of the body, and promoting the rapid advance of putrefaction. (6) Presence or absence of the *rigor mortis*. Bodies may be preserved for months if exposed to intense cold.

The following Table, compiled from the experiments of Devergie, may be of use in aiding the expert to form his opinion, but it must be borne in mind that, from the great difficulties which surround the subject, the statements made are only approximately correct. The table is divided into four stages or periods, the last being that in which putrefaction commences :—

FIRST.—*From a few minutes to twenty hours after death*—Animal heat more or less present, but seldom continuing longer than ten or twelve hours. Muscles contract on the application of galvanic stimuli, and in the earlier stage to blows.

SECOND.—*From ten hours to three days*—Body quite cold and *rigor mortis* well marked ; muscles do not contract on the application of stimuli. The age, mode of death, and other collateral circumstances must, more or less, be taken into consideration before an opinion can be given.

THIRD.—*From three to eight days*—The body is quite cold, and cadaveric rigidity has passed off. The muscles no longer respond to any galvanic or mechanical stimulus. The stage is modified and somewhat shortened in summer.

FOURTH.—*From six to twelve days*—Commencement of putrefaction. Putrefaction may, however, take place on the first or second day after death ; so that, as before stated, care must be taken before any positive decision can be given.

If only the SKELETON remains, the following Table may be of use :—

SEX.—The thorax in the female is deeper than in the male, the sternum shorter and more convex, the ensiform cartilage thinner and

ossified later in life. The cartilages of the ribs are larger, and the ribs smaller than in the male. In the female pelvis the *ilia* are more expanded and horizontal ; the *sacrum* more concave ; the tuberosities of the *ischia* are wider apart and flatter, the *pubis* more shallow ; the cartilage of the *symphysis* broader.

N.B.—The angle formed by the descending *rami* of the *ossa pubis* in the female is more rounded, and the pubic arch wider, than in the male. The diameters of the female pelvis at the brim are—antero-posterior, 4½ ; transverse, 5 ; oblique, 5½ inches. Prior to puberty, the examination of the skeleton affords no evidence of sex.

AGE—Eruption of teeth.

Central incisors,	7	months.	Temporary.
Lateral incisors,	7-10	,,	
First molars,	12-14	,,	
Canine teeth,	14-20	,,	
Second molars,	18-36	,,	

First molar,	6	years.	Permanent.
2 middle incisors,	7	,,	
2 lateral incisors,	8	,,	
First bicuspid,	9	,,	
Second bicuspid,	10	,,	
Canine,	11-12	,,	
Second molar,	12-13	,,	
Wisdom teeth,	18-30	,,	

Examine lower jaw. Ramus forms an obtuse angle in full-grown fœtus, a right angle in adult life, obtuse in old age from loss of teeth.

TABLE SHOWING THE PERIODS AT WHICH POINTS OF OSSIFICATION APPEAR AFTER BIRTH.

YEARS OF LIFE.	Bones in which Centres of Ossification appear.
1.	Fourth piece of the body of the sternum ; coracoid process of scapula ; head of humerus ; os magnum (carpus) ; head of femur ; upper end of tibia ; external cuneiform (tarsus).
2.	Lower end of radius ; unciform (carpus) ; lower end of tibia ; lower end of fibula.
3.	Great tuberosity of humerus ; patella ; internal cuneiform (tarsus).
3-4.	Upper end of fibula.
4.	Great trochanter (femur); middle cuneiform (tarsus).
4-5.	Scaphoid (tarsus) ; lower end of ulna.
5.	Lesser tuberosity (humerus) ; internal condyle (humerus) ; trapezium and semilunar (carpus).
5-6.	Upper end of radius.
6.	Scaphoid (carpus).

YEARS OF LIFE.	Bones in which Centres of Ossification appear.
7.	Trapezoid (carpus).
10.	Upper end of ulna.
12.	Pisiform (carpus).
13-14.	External condyle (humerus); small trochanter (femur).

PERIODS OF UNION OF EPIPHYSES WITH THE SHAFTS OF BONES, AND OF BONES WITH EACH OTHER.

YEARS OF LIFE.	
1-2.	Symphysis of lower jaw.
2.	Frontal suture; unites from below upwards; it may persist. Anterior fontanelle filled up.
7-8.	Rami of ischium and pubis.
17.	Epiphyses of upper end of ulna; small trochanter (femur).
17-18.	Epiphyses of condyles (humerus); upper end of radius.
18.	Epiphyses of great trochanter of femur; lower end of tibia; lower sacral vertebræ; portions of acetabulum united.
19.	Epiphyses of the head of the femur.
20.	Epiphyses of the head of the humerus; lower end of radius and ulna.
21.	Epiphyses of the upper end of tibia; lower end of fibula.
24.	Epiphyses of upper end of fibula.
25.	Second and third pieces of sternum; first and second sacral vertebræ; epiphyses of clavicle, lower end of femur.
40.	Manubrium, with body of sternum.

STATURE.—The bones must be laid out in position, and 1½ to 2 inches allowed for the soft parts.

ANY PECULIARITIES.—False teeth. Malformations, and united or ununited fractures.

N.B.—When only portions of the skeleton are found, no reliable opinion of the height of the individual can be given.

CHAPTER III.

MODES OF DYING, SUDDEN DEATH, SIGNS OF DEATH.

MODES OF DYING.

SYNCOPE—death beginning at the heart.
ASPHYXIA—death beginning at the lungs.
COMA—death beginning at the brain.

Syncope.—From συγκοπτω, *I strike down.* Sudden arrest of the action of the heart.

This condition may be brought about by

1. Deficiency of blood due to hæmorrhage—*death by anæmia.*
2. Effect of certain diseases and poisons, etc.—*death by asthenia.*

Causes—Heart Disease.—Aortic regurgitation, fatty degeneration, etc.

Hæmorrhages from wounds of blood-vessels or the heart, profuse hæmoptysis or hæmatemesis, uterine hæmorrhage, bursting of varicose veins, bursting of aneurysms.

Shock.—Emotion ; blows on the head or epigastrium ; sudden evacuation of fluids from the body, as in emptying an over-distended bladder, tapping a hydrocele, ascites, or a pleural effusion. Extensive injuries to the body (railway and machinery accidents). Drinking large quantities of cold water when heated.

Exhaustive diseases, chronic or infective.

Symptoms.—Pallor of the face and mucous membranes, dimness of vision, cold perspirations, sense of impending death, restlessness, air hunger and gasping for breath, nausea and, maybe, vomiting, noises in the ears, passing delirium, quick,

feeble, and fluttering pulse, or the latter may be imperceptible at the wrist, insensibility, convulsions.

In ordinary fainting attacks many of the above symptoms are absent; such as are present are temporary. In collapse, consciousness is retained.

Post-mortem Signs.—The cavities of the heart contain a normal quantity of blood in death by asthenia, but may be almost empty when death is due to anæmia. The blood in asthenic death is simply arrested in its course; blood is, therefore, found in the large veins and in the arteries. The brain and the lungs are not engorged with blood.

Asphyxia.—From ἀ priv. et σφυξις, *pulse.* Apnœa is the better term—ἀ priv. et πνεω, *I respire*; but this word is now used by physiologists to denote a cessation of the respiratory movements due to artificially oxygenated blood. Blood in this condition fails to excite the respiratory centre in the medulla, and respiration ceases. To avoid confusion the term asphyxia had better be retained, especially as it is most commonly used and generally understood. Asphyxia, or death from defect in the quality of the blood, is brought about when any impediment is placed on the healthy action of the lungs. Experiment has shown that for a short time after respiration has ceased, the heart still continues to act, and that if the impediment to the proper aëration of the air by the lungs be removed, life may be prolonged. Taking therefore the primary meaning of the terms asphyxia and apnœa into consideration, it may be remarked that the latter precedes the former in point of time—asphyxia marking the period at which the action of the heart ceases, apnœa the cessation of the respiratory functions.

Causes of Asphyxia.—1. Mechanical obstruction to the air passages: foreign bodies, exudations, tumours, suffocation, strangulation, drowning, hanging, spasm of glottis from mechanical irritation, or irritant gases.

2. Interference with the action of the respiratory muscles: exhaustion of the muscles from cold; paralysis of muscles from injury to or disease of respiratory centre; poisons acting on the centre; continued pressure on walls of chest; fixation of muscles from tetanus or strychnine poisoning.

3. Diseases of and injuries to the lungs: pleurisy with effusion, acute pneumonia, empyema, pneumothorax, pyopneumothorax, pulmonary apoplexy, embolism of pulmonary artery.

4. Inhalation of air deficient in oxygen.

Symptoms of Asphyxia.—Divided into three stages. *First stage:* deep, frequent, and laboured respiration; the extraordinary muscles of respiration are called into play. *Second stage:* inspiratory muscles less active than expiratory, convulsions of nearly all the muscles of the body. *Third stage:* paralysis of respiratory centres, dilated pupils, loss of consciousness, absence of reflexes. Gasping inspirations with prolonged intervals precede dissolution.

Post-mortem Signs.—Engorgement of the pulmonary artery, the right cavities of the heart, and venæ cavæ; but on the left side of the heart the cavities, together with the aorta and pulmonary veins, are either empty or contain but little blood. It must be remembered, however, that cases of asphyxia do sometimes occur where the cavities on each side of the heart are *empty, or nearly so.* This is the case in the syncopal asphyxia of some writers. If also the obstruction to respiration be imperfect, the circulation may be continued for some time, congestion of one or more of the internal organs being the result. The blood is dark-coloured, contains much CO_2, and the hæmoglobin is almost completely reduced. The blood coagulates slowly.

Coma.—*Causes.*—Concussion of the brain, cerebral hæmorrhage, embolism, thrombosis, tumour, depressed fracture of skull, meningitis, and serous effusions. Effects of poisons such as opium, alcohol, ptomaines, arsenic, barium, oxalic and carbolic acids; in certain diseases of kidneys and liver, uræmia, cholæmia, acetonæmia.

Symptoms of Coma.—Coma is generally preceded by stupor, from which the patient may be roused to a certain extent, but temporarily. The reflexes in this stage may be exaggerated, and the power of swallowing fluids may be retained. When coma is present there is complete abolition of consciousness, the patient is powerless, the breathing stertorous. The temperature may vary according to the cause; normal or subnormal generally, it may rise in lesions of the pons varolii. The pulse is generally full and bounding, the pupils dilated or contracted and insensitive to light, the conjunctival reflex absent. Mucus collects in the air-passages and causes "the death-rattle," and the breathing becomes more and more embarrassed and irregular. The reflexes are lost, and the sphincters relaxed.

Post-mortem Appearances.—Causal lesions found in the brain or other organs, hyperæmia of the brain and spinal cord and their membranes. The condition of the heart and lungs is not constant; the general appearances resemble those in death from asphyxia.

SUDDEN DEATH.

Sudden death may proceed from natural or violent causes. From the former death may occur unexpectedly and very rapidly, but as a rule the period of time occupied by the phenomena of "dying" is measurable, though inconstant. Should such period of time be immeasurable, death may be considered as instantaneous.

Apart from sudden death resulting from violence or poisoning, the common causes are as follows:—

1. Diseases of the heart: angina pectoris, valvular diseases with failure of compensation, especially aortic regurgitation, degeneration of the heart muscle, rupture of the heart, heart failure from diphtheria or toxic diseases.

2. Diseases of the blood-vessels: rupture of aneurysms or varicose veins, thrombosis, embolism.

3. Cerebral hæmorrhage: especially when in the region of the pons varolii or cerebellum.

4. Lesions of the respiratory system: œdema or spasm of the glottis, membranous deposit or foreign bodies in the larynx or trachea, foreign bodies in the pharynx, tumours, whooping-cough, asthma, embolism of the pulmonary artery, air embolism, rupture of a vessel or aneurysm into the air-passages, as in phthisical cavities, pneumothorax, hæmothorax, pleuritic effusion, and in acute pneumonia.

5. Rupture of a gastric ulcer or ulcer of some other part of the alimentary tract.

6. Sudden hæmorrhage into the peritoneal cavity from ruptured uterus, ectopic gestation, etc.

7. Rupture of internal organs: distended bladder, spleen, pregnant uterus, or other abdominal viscus.

8. Hæmorrhage into the pancreas.

9. Conditions associated with the nervous system: mental emotions, epilepsy, uræmia, laryngismus stridulus in children.

10. Sudden death has occurred in Addison's disease, in diabetes, during simple vaginal examination in women, during

the injection of fluids into the vagina or uterus. Bouvalat (*Annales d'Hygiène*, 1892) relates a case in which, as the cannula of a syringe was being introduced into the os uteri of a woman with the object of criminal abortion, she fell back before any fluid was injected, and died in a few minutes.

A similar case came under my notice, in which death took place while the husband of the woman was introducing a solution of 20 minims of tincture of iodine, mixed with water to measure two drachms, into her uterus through a No. 3 catheter (R. J. M. BUCHANAN).

SIGNS OF DEATH.

REAL OR APPARENT DEATH.

It will be unnecessary here to discuss any of the theories put forward with regard to cases of apparent death or prolonged trance, but simply to note in the order of their occurrence the phenomena which attend real death.

Real Death.

Under this heading it is important to draw a distinction between "Somatic death" and "Molecular death." "Somatic death" is defined as "the cessation of the vital functions and of the general renewal of tissue consequent on that cessation"; "Molecular death" is the death of the tissues themselves.

The signs of death occur as follows :—

1. *Entire and continuous cessation of the respiration and circulation; no sounds heard on auscultation.* The absence of the heart sounds is the most important sign of death, for even in the severest forms of syncope the cardiac pulsations, as shown by M. Bouchat, can with care be heard.

Tests for cessation of respiration :—

(*a*) Auscultation.

(*b*) Placing a hand mirror or empty drinking-glass over the mouth or nostrils, or a light feather, and noting the presence or absence of bedewing or movement.

(*c*) Placing a shallow vessel, such as a saucer, full of water on the chest or abdomen, and observing the presence or absence of rippling of the fluid (Winslow's test).

Tests for cessation of the circulation :—

(*a*) Auscultation.

(*b*) Manual exploration of the principal arteries for pulsation or thrill.

(*c*) Magnus's test, applying a ligature tightly round a finger, and noticing whether or not a bloodless ring forms at the seat of ligature, and a zone of livid redness on the distal side of the ligature.

(*d*) Applying pressure to the finger-nail, and noticing whether the colour disappears on pressure, and a pink tinge appears after relaxing the pressure.

(*e*) Applying heat, such as dropping melted sealing-wax on the skin, and noting whether or not redness or vesication ensues.

(*f*) Holding the hand, with the fingers abducted, against a strong light, and observing whether or not the web of the fingers is translucent.

(*g*) Inserting a brightly polished needle into a fleshy part of the body, allowing it to remain for ten seconds or so *in situ*, and noticing whether it is tarnished or not on withdrawing it.

(*h*) Injecting hypodermically a solution of fluorescin (resorcin-phthalein and sodium bicarbonate, a gramme of each dissolved in 8 c.c. of water). No local discoloration of the skin takes place if the circulation has ceased, but if not, a yellowish-green coloration of the skin occurs round the seat of injection, and the substance may be detected in the blood at a part some distance from the seat of injection. By immersing some white silk threads in the blood drawn at a distance from the prick, then boiling them in distilled water, the latter will have a greenish colour if the fluorescin has been circulated (Icard's test).

These tests will detect whether the circulation has ceased or not, and so differentiate suspended animation from real death.

2. The *lustre of the eye* is lost immediately after death. It has, however, been stated that the iris will respond to the action of atropine and Calabar bean for as long as twenty-four hours after death, and that the action of the latter is always more marked than that of the former. A blackish round or oval stain has been described by M. Larcher on the sclerotic coat on the outer side, which he calls *l'imbibition cadavérique*

du fond de l'œil. It is probably due to thinning of the sclerotic from evaporation, enabling the choroid to be seen through it. The spot precedes rigidity and is a forerunner of putrefaction.

3. The *most powerful stimulus applied to the body does not cause any reaction.* The muscles *may*, however, be made to contract shortly after death by the stimulus of a slight blow, or by galvanism.

4. *The surface of the body becomes of an ashy-white colour.*

EXCEPTIONS.

(1) Persons of florid complexion retain this on the malar prominences for some time after death.
(2) The red or livid edges of ulcers.
(3) Blue, black, or red tattoo marks, if not effaced during life, do not disappear.—Ecchymoses retain the hue they had at the time of death.
(4) An "icteric" coloration existing at death never becomes white. Death from jaundice.
(5) A rosy tint of the skin described by Devergie, on those poisoned by carbonic acid.
(6) Dusky red patches in those frozen to death.
(7) In certain cases of drowning, a rosy colour may be observed on the lips and malar prominences.

5. The *temperature of the body* at the time of death is retained for some time. Cooling will depend on the medium in which the body is placed, and mere coldness of the body is not a sign of death. Average internal temperature of body during life, 98° to 100° F.

(1) Fat persons retain the heat longer than lean ones; adults longer than children or old persons. Bodies are cooled by—1. Radiation. 2. Conduction. 3. Convection.
(2) Bodies immersed in water cool more rapidly than in air. This fact may be of importance in determining survivorship in a case of drowning.
(3) Bodies in bed and covered by the clothes, or in cesspools and in dung-heaps, cool less rapidly than when exposed.
(4) Persons killed by lightning keep longer warm than others (?).
(5) Death by suffocation retards the process of cooling.
(6) The body may be cold externally, but possesses a considerable amount of heat when the internal organs are exposed. Persons who have died of cholera, yellow fever, or suddenly of some acute disease—rheumatism—may retain for some hours a considerable amount of heat. It has even been asserted that in some diseases—cholera—there is an increase of temperature soon after death (LAYCOCK), also after death due to some diseases of the nervous system.

(7) Most bodies, under ordinary circumstances, are, as a rule, quite cold in from eight to twelve hours after death.

6. *Relaxation, primary flaccidity, more or less general, of the muscular system takes place.*

"*If the above signs are alone present, death must have taken place in from ten to twelve hours at the longest*" (Casper). *Exception: cadaveric spasm.*

7. *Want of elasticity in the eyeball: flaccidity of the iris.* This condition invariably occurs in from twelve to eighteen hours after death.

8. *Flattening of the muscles* of those parts on which the body rests, due probably to loss of vital turgidity.

9. *Hypostasis.* Suggillation, or *post-mortem* staining, is due to the gravitation of the blood to the most dependent parts of the body not subject to direct pressure. The hypostatic marks begin to form in from eight to twelve hours after death, and increase in size till putrefaction sets in. Hypostasis may be mistaken for an ecchymosis or a bruise, and in the lungs for congestion, inflammation, etc. Errors may also occur with regard to the brain, kidneys, and intestines: in the last, the redness of inflammation is seen all over the parts, whereas the coloration of hypostasis is interrupted, and this is best shown by drawing out the convolutions. The heart is an exception to the rule, but it may contain clots varying in size and colour, and known as *polypi*. These are *post-mortem* formations. The use of the word suggillation is objectionable, as it has been used in opposite senses by Continental and British authors—some writers restricting the term to ecchymosis proper, others using it as synonymous with cadaveric lividity or external hypostasis.

Cutaneous Hypostasis.

(1) *Meaning of the expression.*—The gravitation of the blood in the capillaries after death, in obedience to the laws of inert matter.

(2) *On what parts of the body usually seen?*—On the most dependent parts of the body; on the whole of the back of the body, if the body be supine. The patches are irregular and slashed, terminate abruptly, and do not fade gradually into the surrounding colourless skin.

(3) *At what period after death first observed?*—In from eight to twelve hours, gradually extending in size till putrefaction sets in.

(4) *Whether or not affected by death from hæmorrhage?*—Formed after every kind of death, even after death due to hæmorrhage, although the coloration may not be quite so marked.

(5) *With what result of external violence sometimes confounded?*—Liable to be confounded with ecchymosis, the result of injury. Hypostasis must also not be confounded with the livid patches seen on the legs and feet of aged persons and on those who have died from typhus, etc. The livid patches—"frost erythyms,"—seen on those who have died from exposure to cold, must not be mistaken for ecchymosis. The above patches are as frequently on the upper surfaces of the body as on the lower, and are not so extended as cadaveric lividities ; the blood, moreover, which gives rise to them is diffused through the areolar tissue, and not incorporated with the true skin.

(6) *How distinguished from this?*—Effused or coagulated blood is found when an incision is made in a *true* ecchymosis, however small, whereas a few bloody points are alone seen on a slight or deep incision into a *post-mortem* stain or true hypostasis. The seat of hypostasis is the superficial layer of the true skin. Hypostases are never raised above the surface, as ecchymoses sometimes are. In describing these two conditions, "ecchymosis" and "hypostasis," it is preferable to describe the former as "discoloration from extravasated blood," and the latter as "lividity after death."

10. *Cadaveric rigidity.* From the moment of death till the time when putrefaction sets in, the muscular structures of the body may be said to pass through three stages :—

(1) *Muscular Irritability.*—The muscles flaccid, but still possessing the power of contractility on the application of certain stimuli. Parts contracted during the act of dying—cadaveric spasm,—as the muscles of the hand grasping a knife or other weapon, may continue so for some time after death.

(2) *Cadaveric rigidity.*—A state of rigidity, the power of contractility absent.

(3) *Commencement of Putrefaction and Chemical Change.*—Relaxation again present ; all power of contraction lost, not to be regained.

Cadaveric rigidity, or *rigor mortis*, is a purely muscular phenomenon, and is not dependent on the nervous system, as it is not prevented, though it may be delayed, by division of the nerves, and is as well marked in paralysed as in non-paralysed limbs. Cadaveric rigidity, which occurs early in the heart, must not be mistaken for hypertrophy, or its absence for dilatation. In every case the *rigor mortis* precedes putrefaction, and consists in a shortening and thickening of certain muscles, chiefly the flexor and adductor muscles of the extremities, and also the elevators of the lower jaw.

This condition commences in the involuntary muscles, and in the heart may simulate hypertrophy of that organ, then passes into the voluntary muscles of the back of the neck and lower

jaw, and then into the muscles of the face, front of the neck, chest, and upper extremities, and then into the trunk muscles, and last of all, into those of the lower extremities. It, in most cases, passes off in the same order, the body becoming quite flaccid, the *rigor mortis* never returning. These phenomena occur whilst the body is cooling. The muscle becoming rigid is dying, the rigid muscle is dead. The cause of the *rigor mortis* is by no means evident. By some it is held to be due to the coagulation of the albuminous transverse bands seen in all voluntary muscles; by others, to the coagulation of the fibro-albuminous fluid found between the fibres of muscle.

Cadaveric rigidity generally supervenes from *eight* to *twenty* hours after death, and may continue from a few hours to four or nine days.

The sooner rigidity comes on after death the sooner will it pass away, and the later the onset the longer it will last. It is a general rule that whatever exhausts the muscular irritability before death causes the early appearance and the more rapid disappearance of *rigor mortis.*

Conditions which modify the onset and duration of *rigor mortis*:—

(1) *Age.*—Transitory *rigor mortis* may appear in the immature fœtus according to the state of its muscular development.

It is feeble and disappears quickly in infants and young children.

It is usually well marked in adolescents and healthy adults, but feeble in old people.

(2) *The Degree of Muscular Development of the Body.*—Other things being equal, the greater the muscular development and muscular strength at the time of death, the slower is the onset of *rigor mortis*, and the longer its duration; the more feeble or exhausted the muscular condition, the more rapid the onset and the shorter its duration.

(3) *The Temperature of the Environment of the Body.*—In temperate and colder climates *rigor mortis* follows the usual course. A low temperature, below freezing-point, will retard the onset and favour the duration of *rigor mortis*, but if the body be suddenly thawed before *rigor mortis* has set in, it will appear rapidly and disappear more quickly than if it had not been subjected to the process of thawing.

If a body already in a condition of early rigidity be exposed to a temperature of 75° C., the rigidity becomes more marked, since albuminates in the muscles, other than the myosin, become coagulated in addition. This phenomenon has been called *heat stiffening.*

(4) *Mode of Death.*—After all exhausting diseases of long or short duration, *rigor mortis* appears early and passes off quickly, as in death

from phthisis, cholera, typhus fever, typhoid, hydrophobia, scurvy, and occasionally in chronic Bright's disease.

Death during alcoholic intoxication favours the duration of *rigor mortis.* After violent muscular exercise death is quickly followed by rigidity. Animals that have been hunted for some time before death stiffen very rapidly. When convulsions precede death, *rigor mortis* sets in early as a rule, but in certain cases, where death has been preceded by strong convulsions, rigidity may appear quickly, but last for some days, as in some cases of poisoning by strychnine.

Conditions which simulate *rigor mortis* :—

(1) *Stiffening by Catalepsy.*—In this condition the temperature of the body' will remain at a degree compatible with life over a period incompatible with real death. If a limb be extended and rigid in catalepsy, after passive flexion of it, it will return to its former state.

(2) *Rigidity from the Body being Frozen.*—In this condition passive movement of the joints is accompanied by crackling due to fracture of their frozen contents.

(3) *Heat Stiffening.*—Is seen in the bodies of persons who have been suddenly immersed in boiling fluids ; also to a certain degree in bodies of persons who have met their death by burning from paraffin-lamp accidents.

Cadaveric Spasm or Instantaneous Rigor.—"When this phenomenon occurs the last act of life is crystallised in death." It is a prolongation of the last vital contraction of the muscles into the rigidity of death. Cadaveric rigidity of the muscles must be distinguished from *muscular spasm* occurring at the moment of death.

They may thus be distinguished :—In cadaveric rigidity any object placed in the hand prior to the onset of *rigor mortis* can be readily removed, even if the precaution be taken of binding it in the hand prior to the accession of *rigor mortis.*

In the case of *muscular spasm* the object is found grasped in the hand, and can only be with difficulty removed.

The difficulty experienced in removing a pistol or other weapon from the hand may point to suicide ; its easy removal to homicide, the weapon having been placed there after death.

No adequate explanation of this phenomenon has yet been made. It is not an unusually early onset of *rigor mortis* in the muscles affected, because they do not share in the initial relaxation that precedes it, or the weapon would fall from the hand,

and the bodies would not retain the peculiar attitudes which have been described in different instances. Nothing can simulate cadaveric spasm, and it cannot be produced in any way after death. Instantaneous rigor only occurs in cases in which there has been great mental tension and nerve excitation before death. It is a continuation of probably the very last voluntary act of life.

A body showing the signs of death before mentioned (Nos. 1 to 10) *may be held to be that of a person who has been dead from two to three days at the longest* (Casper).

Muscular states of the body between the period of somatic and molecular death :—

(1) *Primary Flaccidity.*—The muscles respond to electrical stimuli ; the chemical reaction of the muscles is either neutral or faintly alkaline.

(2) *Cadaveric Rigidity* or *Rigor Mortis.*—During this condition molecular death takes place ; the muscles do not respond to stimuli, and their reaction is markedly acid.

(3) *Secondary Flaccidity.*—Disintegration of the muscular elements takes place, no stimuli will provoke response, and the reaction again becomes alkaline.

Table showing the Principal Points to be noted in the period of accession of Cadaveric Rigidity, and the causes which retard or hasten its appearance, or modify its duration :—

In what does it consist?—In a shortening and thickening of the muscles, particularly the flexors and adductors of the extremities, and elevators of the lower jaw.

Period of Invasion.—Generally in from eight to twenty hours after death. It has been known, however, to supervene within three minutes of death, but it may be delayed for sixteen or seventeen hours.

Period of Duration.—From one to nine days. Three weeks (Taylor).

Order in which the Muscles are affected.—Involuntary muscles, back of neck and lower jaw, muscles of the face, front of the neck, chest, upper extremities and then the lower extremities.

Order in which it disappears.—Back of neck, lower jaw, etc., following the course of its accession.

Effects of Exposure to Cold.—Prolonged by dry cold air, and by cold water.

Effects of Enfeebling Disease prior to Death.—Rapid in its invasion, and passing off rapidly.

Effect of a Robust Frame at Period of Death.—The accession may be prolonged ; but, other things being equal, it is more strongly manifested, and continues longer.

Effects of Violent Exercise prior to Death.—Rapidly supervenes and rapidly disappears, as in soldiers killed at the end of a battle.

Effects of Poison.—Poisons which cause violent contractions for some time prior to death—strychnine, etc.—influence the rapid invasion of the *rigor mortis*, its short duration, rapidly followed by putrefaction. Where death in poisoning by strychnine is almost instantaneous, with a short convulsive stage, *rigor mortis* comes on *rapidly* and remains a *long* time.

11. *Putrefaction*—the last of the phenomena which follow death—is the resolution of the organised tissues of the body to the inorganic state. It is a gradual process, and is the result of the action of *micro-organisms, aided by moisture, air, and warmth.*

Putrefaction is the only absolute sign of death having taken place.

The *conditions which modify putrefaction* are as follows:—

External Conditions.—1. Micro-organisms; 2. Air; 3. Moisture; 4. Warmth.

Internal Conditions.—1. Age; 2. Sex; 3. Condition of the body—(*a*) *Constitutional peculiarity;* (*b*) *State of the body.* 4. Kind of death—(*a*) *The result of disease;* (*b*) *The result of poisons.*

External Conditions which Modify Putrefaction.

1. *Micro-organisms.*—A fauna and flora of decomposition has been described in a paper by Hough on "The Fauna of Dead Bodies," *B. M. J.* vol. ii. 1897, p. 1853, to which the reader is referred.

Many different forms of micro-organisms combine in the production of putrefaction, and the result of their action is inevitable, unless the body be guarded against their invasion by special means, or the tissues be rendered unfit for their use.

2. *Air.*—Exposure in the open air has a marked effect in promoting putrefaction; but garments fitting close to the body, and thus excluding air, have a contrary effect. Dry air, or air in motion, by assisting evaporation from the corpse, acts as a preservative. The composition of the soil in which the body is placed has also a more or less modifying effect. In light, porous soil, allowing of the free ingress of air, decomposition is more rapid than in close, compact soil, as clay; but in this we have to contend with another agent—moisture—which more or less counteracts the protective virtue of the closer earth.

3. *Moisture.*—Putrefaction cannot proceed without moisture. The body, however, contains sufficient water to enable this process to commence spontaneously. Organic substances artificially deprived of water do not putrefy. Cold and heat possess marked antiseptic properties—the former by freezing the fluids in the body, the latter by drying them up.

4. *Warmth.*—A temperature between 70° and 100° F. is found most favourable to decomposition. The effect of cold is shown by the fact that a body immersed in water during winter, at a temperature between 36° and 45° F., may be so well preserved as to present, ten or twelve days after death, well-marked signs of violence, which would in summer have been utterly obliterated in five or seven days. The preservative influence of cold water will, however, depend greatly on the depth at which the body has been submerged. Bodies so submerged, and then exposed to the air, putrefy with such rapidity that exposure for one day is said to work a greater change than three or four days' longer retention of the body in the water. As an instance of the preservative power of cold, may be mentioned the mammoth found in Siberia embedded in a block of ice.

Internal Conditions which Modify Putrefaction.

1. *Age.*—The bodies of young children, other things being equal, are said to putrefy rapidly. It should be remembered, however, that clothing possesses considerable power in retarding putrefaction, and that, in the hurry and anxiety to get rid of the infants, they are oftener exposed naked than clothed, which may, in some measure, account for their more rapid decomposition.

2. *Sex.*—Sex, it would appear, has little or no influence either to retard or hasten putrefaction; but it has been remarked that females dying during or soon after child-birth, irrespectively of the cause of death, putrefy most rapidly.

3. *Condition of the Body.*

(*a*) *Constitutional Peculiarity.*—It is generally admitted that persons of the same age and sex, dying similar deaths, and subjected to like conditions as to exposure to the air and interment in the same soil, exhibit marked differences as regards the accession and rapidity of putrefaction. The explanation may be difficult, but the fact still remains.

(*b*) *State of the Body.*—Fat and flabby corpses putrefy more rapidly than the lean and emaciated. Hence old people, who are generally thin, keep fresh for a comparatively long time. Bodies, also, which are much mutilated rapidly decompose—decomposition setting in first at the parts injured. In examining wounds and bruises said to have been inflicted during life, it is well to remember that the tendency of putrefaction is to make them appear more severe.

4. *Kind of Death.*

(*a*) *Effect of Disease.*—Healthy persons dying suddenly, other things being equal, are said to decompose more slowly than those who have died from exhausting diseases, as in the case of typhoid, phthisis, and dropsy, following organic disease, or of those diseases attended with more or less putridity of the fluids.

(*b*) *Effects of Poisons.*—Putrefaction rapidly supervenes in those who have died suffocated by smoke, by carbonic oxide, and by sulphuretted hydrogen. Narcotic poisoning is stated to accelerate this condition; but in poisoning by phosphorus, alcoholic blood-poisoning, and in cases of death from sulphuric acid, the putrefactive changes are greatly retarded. The manner in which death takes place from the action of the poison greatly hastens or retards putrefaction. Thus, in the case of poisoning by strychnine, it is found that when death has occurred rapidly, without much muscular exhaustion, putrefaction sets in slowly; but that, when the muscular irritability has been greatly exhausted by successive fits, the contrary is the result. Arsenic, chloride of zinc, and antimony are reputed to possess antiseptic properties.

THE PHENOMENA OF PUTRESCENCE IN THEIR CHRONOLOGICAL ORDER.

I. EXTERNAL.

One to Three Days.—Greenish coloration of the abdominal walls. Odour of putrescence is gradually developed, and, concurrently with this, the eyeball becomes soft and yielding to pressure.

Three to Five Days.—The green colour, of a deeper shade, has now passed over the abdomen, extending also to the genital organs. Patches of this green coloration also make their

appearance somewhat irregularly on other parts of the body, such as the neck, back, chest, and lower extremities. A dark reddish frothy fluid about this time wells up from the mouth.

Eight to Ten Days.—The patches of green colour have now coalesced, so that the whole body is discoloured. On some parts of the body the colour is of a reddish green, due to the presence of decomposed blood in the cellular tissue. The abdomen is now distended with gases, the products of decomposition. In India this distension has been known to occur in less than six hours, the average period being a little over eighteen hours. Much depends upon the season of the year. The colour of the eyes has not disappeared, but the cornea have fallen in. Relaxation of the sphincter ani takes place, and the superficial veins appear like reddish-brown cords. The nails still remain firm.

Fourteen to Twenty Days.—The colour of the surface is now bright green, with here and there patches of a blood and brown colour. The epidermal layer of the skin is raised in bullæ of varying size, in some places the skin being more or less stripped off. The nails are detached, and can be easily removed. The hair can be pulled from the scalp with ease. The body is now greatly distended with gases, and the features cannot be recognised, owing to the swollen condition of the face. The body is generally covered with vermin. In determining the time at which death occurred, it will be necessary to take into consideration the season of the year, as it is found that an advanced stage of decomposition may be present in from eight to ten days, with the thermometer ranging between 68° and 77° F., which in winter, with a temperature of from 32° to 50° F., would require twenty to thirty days. "*Bodies green from putridity, blown up and excoriated, at the expiry of one month, or from three to five months after death* (*cæt. par.*), *cannot with any certainty be distinguished from one another*" (CASPER).

Three to Six Months.—During the above period the stage of colliquative putrefaction has set in. The thoracic and abdominal cavities, due to the increased formation of gas, have burst. The bones of the cranium have more or less separated, allowing the brain to escape. The soft parts are more or less absorbed, and no recognition of the features is possible. The sex can only be positively made out by the presence of a uterus, or by the peculiar growth of hair on the pubes, which in woman

only covers the pubes, but in man extends upwards to the navel.

Saponification.—Bodies exposed to the action of water, or buried in damp, moist soil, are apt to undergo certain changes, in the course of which they become saponified, and the formation of a substance known as *adipocere* is the result. Adipocere—*adeps*, lard, and *cera*, wax—is chiefly composed of margarate of ammonia, together with lime, oxide of iron, potash, certain fatty acids, and a yellow-coloured odorous matter. The melting-point is 126·5° F. Adipocere has a fatty, unctuous feel, is either pure white or of a pale yellowish colour, and with the odour of decayed cheese. The formation of this substance "to any considerable extent is not likely to occur in less than three to four months in water, or six months in moist earth, though its commencement may take place at a much earlier period" (Casper). The above-quoted authority mentions a case in "which the remains of a fœtus were found imbedded in adipocere, and which fœtus was proved to have been buried in a garden exactly six months and three-quarters." Taylor also records the case of a bankrupt who committed suicide by drowning, in which the muscles of the buttocks were found converted into adipocere in five weeks and four days at the longest.

Although the above statements may be accepted with regard to the formation of adipocere as far as European countries are concerned, they do not seem to be applicable to India, where the change appears to be more rapid. Dr. S. Coull Mackenzie, in his valuable little book on *Medico-Legal Experiences in Calcutta*, records a case of a young man whose body, recovered after seven days' immersion in the river Hooghly, "was found to be in an advanced state of saponification," and the fleshy portions of undigested food in the stomach were converted entirely into adipocere. "Lastly," he writes, "in the hot, steamy, rainy months of September and October, in three of the cases above mentioned, saponification was found in bodies immersed in water, both externally and internally, in from two days to eight days ten hours. In the soft and porous soil of Lower Bengal during the rainy seasons, even in a wooden coffin, the change is very rapid—three or four days."

To explain the formation of adipocere, it has been supposed to be due to the decomposition of the muscular structures of

the body, by which hydrogen and nitrogen are evolved, these combining to form ammonia, and this, coming in contact with the fatty acids of the fat, forms a soap. The process of saponification takes place most rapidly in young fat persons; next, in those adults who abound in fat, and in those whose bodies have been exposed to the soil of water-closets—more rapidly in running than in stagnant water; and lastly, in those who have been buried in moist, damp soil, especially if the bodies have been piled one on the top of the other, the lowest being first saponified. The muscular tissue appears to be the first to undergo this change. In water the process is said to be completed in about five months, but in soil a period of two or three years appears necessary.

Mummification is of no medico-legal interest, as the causes which produce it are unknown, and no reliable data can be obtained as to the period of its accession, or the time required for its production.

TABLE showing the order in which the Internal Organs undergo Putrefaction:—

1. The Trachea.	9. The Heart.
2. The Brain of Infants.	10. The Lungs.
3. The Stomach.	11. The Kidneys.
4. The Intestines.	12. The Bladder.
5. The Spleen.	13. The Gullet.
6. The Omentum and Mesentery.	14. The Pancreas.
	15. The Diaphragm.
7. The Liver.	16. The Blood-vessels.
8. The Adult Brain.	17. The Uterus.

II. INTERNAL.

ORGANS WHICH PUTREFY EARLY.

1. *The Trachea, including the Larynx.*—This rapid change in the trachea must be borne in mind, in order to avoid the error of attributing death to suffocation or drowning. An examination of the trachea should never be omitted.

2. *The Brain of Infants up to the First Year.*

3. *The Stomach.*—The first traces of putrefaction are seen in from four to six days after death. All the coats of the stomach are softened, but there is no excoriation, as is the case when corrosive poisons are taken. Emphysematous separation of the mucous coat may be present, but must not be confounded with the excoriation just mentioned.

4. *The Intestines.*—Casper declares that he does not remember any case in the course of his experience where the intestines were "found earlier putrefied than the stomach." In the course of putrefaction they become of a dark brown colour, bursting, and allowing an escape of their contents; and they ultimately become changed into a dark pultaceous mass.

5. *The Spleen.*—This organ in some cases putrefies before the stomach and intestines; but, as a rule, it resists decomposition longer.

6. *The Omentum and Mesentery.*

7. *The Liver.*—This organ is not unfrequently found firm and dense some weeks after death. It putrefies earlier in newborn children than in adults. The convex surface first shows signs of putrefaction. The gall-bladder also remains for some time recognisable.

8. *The Adult Brain.*—The brain of newly-born children, as mentioned before, soon putrefies. This is not the case in the adult brain. Putrefaction sets in not on the surface, but at the base of the brain. A wound of the brain causes it to putrefy more rapidly than if no injury be present.

Organs which Putrefy Late.

9. *The Heart.*

10. *The Lungs.*—Contemporaneously with the appearance of decomposition in the heart, the lungs also begin to show signs of putrefaction, though this condition may take place earlier.

11. *The Kidneys.*—These organs are long in yielding to the putrefactive process.

12. *The Bladder.*—Nearly all the other organs of the body are in a state of decomposition before this viscus becomes materially affected.

13. *The Gullet.*—This long remains firm, even after the stomach and intestines fail to be recognised.

14. *The Pancreas.*—The body must be far advanced in putrefaction before this gland becomes affected.

15. *The Diaphragm.*—This may be distinguished after the lapse of four to six months.

16. *The Blood-vessels.*—The aorta may be recognised after the body has been interred for fourteen months.

17. *The Uterus.*—Of all the organs of the body, the uterus resists the putrefactive changes longer than any other organ.

TABLE showing some important Facts to be noticed with regard to Putrefaction:—

1. Earliest external indication of it.

   (1) *In a Body exposed to Air.*—Greenish coloration of the abdominal coverings.

   (2) *In a Body immersed in Water.*—Face, head, and ears, gradually extending from above downwards.

2. Earliest internal indication.—Found in the trachea, including the larynx.

3. Advanced putrefactive appearances to be expected in a body exposed to air, say from fourteen to twenty days at mean temperature, as regards—

   (1) *Epidermis.*—Raised here and there in blisters about the size of a walnut, in some places the size of a dinner-plate, and quite stripped off.

   (2) *True Skin.*—Maggots cover the body, chiefly in the folds of the skin.

   (3) *Cellular Tissue.*—Blown up with gas.

4. Comparative time required to produce equal extent of putrefaction in a body—

   (1) *In Air.*—One week. One month.

   (2) *In Water.*—Two weeks. Two months.

   (3) *In Earth.*—Eight weeks. Eight months.

Does Lime hasten Putrefaction?—It is a very general opinion that it does. Careful experiment has, however, proved that lime neither retards nor hastens putrefaction, but that it prevents the escape of the gases produced during the process by absorbing them; it is, therefore, a good and safe deodoriser, and in this property its true value lies.

CHAPTER IV.

POST-MORTEM EXAMINATIONS AND EXHUMATIONS.

The following are some of the Instructions issued to Medical Inspectors by the Crown Office in Scotland, slightly modified :—

I. Part of General Directions.

13. When any portions of the body, or any substances found in or near it, are to be preserved for further examination, they ought never to be put out of the custody of the inspectors, or of a special law officer. They must be locked up in the absence of the person who keeps them. When they are to be transmitted to a distance, they should be labelled, and the labels signed by the inspectors ; and after being properly secured and sealed, they should be delivered by the inspectors themselves, or the special law officer whose duty it is to see them delivered into the hands of the parties for whom they are intended.

II. Necessary Implements.

14. Besides the ordinary instruments used in common dissections, the inspector should be provided with a foot-rule for measuring distances, and a glass measure graduated to drachms, for measuring the quantities of fluids, two or three stoneware jars of medium size, or when these cannot be had, a few clean bladders, for carrying away any parts of the body which it may be necessary to preserve for future examination, and in cases of possible poisoning, three or four bottles of eight, twelve, and sixteen ounces, with glass stoppers or clean corks, for preserving fluids to be analysed. The common square green glass pickle bottles are very suitable, and can generally be obtained. No bottle or jar should be used until it has been thoroughly washed under the supervision of one of the inspectors. In cases of infanticide a balance, having a flat scale-pan with a foot-rule painted on it, is of great use ; on it the infant may be stretched, weighed, and measured at one operation. Paper, pens, ink, and sealing-wax should also be provided.

15. All distances, lengths, surfaces, and the like, whose extent may require to be described, ought to be accurately measured ; and the same rule ought to be followed in ascertaining the volume of fluids. When large quantities of fluids are to be measured, any convenient vessel may

be used, whose capacity is previously ascertained by the inspectors. Conjectural estimates and comparisons, however common, even in medico-legal inspections, are quite inadmissible.

III. External Aspect, and Examination of the Body.

16. The importance of the external examination, and the particulars to be chiefly attended to in performing it, will vary in different cases with the probable cause of death. It comprehends an examination—(1) Of the position of the body when found, as well as of all external injuries or marks presented by it. (2) Of the vicinity of the body, with a view to discover the objects on which it rested, or from or upon which it may have fallen, marks of a struggle, signs of the presence of a second party about the time of death or after it, weapons or other objects the property or not the property of the deceased, the remains of poisons, marks of vomiting; and where marks of blood are of importance, and doubts may arise as to their really being blood, the articles presenting them must be preserved for further examination. (3) Of the dress, its nature and condition, stains on it of mud, sand, or the like, of blood, of vomit, of acids, or other corrosive substances, marks of injuries, such as rents or incisions; where injuries have been inflicted on the body, care should be taken to compare the relative position of those on the body and those on the clothes; and where stains, apparently from poison, are seen, the stained parts are to be preserved for analysis. (4) Ligatures, their material and kind, as throwing light on the trade of the person who applied them; the possibility, or impossibility, of the deceased having applied them himself; their sufficiency for accomplishing their apparent purpose, etc.

17. The inspectors will commence the examination of the body itself by surveying the external surface and openings. Before cleaning it they will examine it on all sides, not neglecting the back, as is often done, and look for marks of mud, blood, ligatures, injuries, stains from acids, and the like; foreign bodies, or injuries within the natural openings of the body, viz. the mouth, nostrils, ears, anus, vagina, and urethra. If there are impressions of finger-marks, they will consider which hand produced them. If there be any doubt about stains being blood, the skin presenting them must be preserved for analysis. If there be acid stains, or other probable remains of poison, or any foreign matter, the nature of which may require to be determined by analysis, these must also be preserved. The ordinary places for the impressions of ligatures are the neck, the wrists, the ankles, and the waist. The degree of warmth of the trunk and extremities, the presence or absence of cadaveric rigidity, and whether it exists equally in the upper or the lower extremities, should be noted in this stage of the proceedings; in other cases the progress of putrefaction, as indicated by the odour of the body, the looseness of the cuticle, the colour of the skin, and formation of dark vesicles on it, the evolution of air in the cellular tissue, the alteration of the features, the softness of the muscles, the shrivelling of the eyes, the looseness of the hair and nails.

18. In this part of the examination it will sometimes be necessary to observe the particulars by which the body may be identified. These are numerous. But the most important are the stature, the age and sex,

the degree of plumpness, the size and form of the nose and mouth, the colour of the eyes and hair, the state of the teeth, warts, nævi, deformities, scars of old abscesses, ulcers, and wounds, and, if a woman, marks of her having had one or more children.

19. The body is next to be washed, if necessary, and the hair of the head shaved, or at least closely cut; and a thorough examination of the whole integuments is to be made. At this stage the inspectors will look particularly for the appearance of lividity, noting its chief seat and its relation to the posture in which the body was found—for impressions on the skin of objects on which it had rested—for marks of injuries, more especially contusions, taking care to ascertain their real nature by making incisions through the skin—for marks of disease, such as eruptions, ulcers, and the like—for marks of burning—for marks of concealed punctures in the nostrils, mouth, external openings of the ears, the eyes, the nape of the neck, the arm-pits, the anus, the vagina, and beneath the mammæ or scrotum; in infants, also in the fontanelles and the whole course of the spine. At this stage, wounds and other injuries should be carefully examined according to the directions given in Division V. (*infra*). Where the injury may have caused loss of blood, the presence or absence of pallor of the skin, lining membrane of the mouth, and the gums ought to be noted.

IV. Dissection, or Internal Examination of the Body.

20. In commencing the dissection of the body, it must be laid down as an invariable rule that all the great cavities should be examined, and also every important organ in each, however distinctly the cause of death may seem to be indicated in one of them. It is right to examine the cavity of the spine, and at all events its upper portion, in any case where an unequivocal cause of death has not been discovered elsewhere.

21. In examining the organs situated in the several cavities of the body the inspectors must be guided in a great measure by their ordinary anatomical and pathological knowledge.

22. The inspectors should begin with that cavity over which there is a wound or other mark of injury. Or, if there be an injury on the extremities, the dissection ought to commence there. In the absence of any such guide, that cavity should be taken first where the circumstances of death, so far as they are ascertained, may lead the inspectors to expect unusual appearances. In other cases, the abdomen should be first opened but *not* dissected, and a general survey made of the parts exposed, without disturbing them materially, the position of the diaphragm being determined by examining it with the hand; then the thorax is immediately to be examined, unless there is good reason for doing otherwise. The reasons for this method of procedure are as follow:—If the abdominal organs are removed, and the veins cut, the blood in the heart may drain away through the venæ cavæ, and error result. If, on the other hand, the thorax be first opened, the relation of the abdominal organs to each other cannot be clearly made, owing to the relaxation of the diaphragm, due to the severing of its thoracic connections. Again, if the thorax be first opened, the position of the diaphragm cannot be determined. The inspectors may begin with the

head, which may be examined thoroughly in the first instance, afterwards the chest and belly, as above described; the spine being reserved till the conclusion. Wherever unusual appearances are discovered in the first cursory survey, the anatomical examination ought in general to be begun there.

23. In examining the several regions of the body it is to be observed that wherever a wound, or other obvious injury of the external parts, lies in the way of the ordinary incisions, that part must be avoided, so as to leave the external injury unaltered.

24. The most approved mode of opening the head in medico-legal cases is, after dividing the integuments from ear to ear, and reflecting the scalp over the forehead and occiput, to make the usual circular incision through the skull, about an inch above the orbits in front, and over the occipital protuberance behind, using the saw lightly and carefully after the outer table of the skull has been divided, so as to avoid injuring the membranes of the brain; and to raise the skull-cap from before backwards, taking care to detach the dura mater from the skull with the handle of the scalpel or a spatula where it adheres firmly. The chisel and mallet should never be used where there is any chance of finding a fracture of the skull; for how could it be distinguished from a fracture made with the mallet? Should the dura mater be firmly adherent to the skull-cap, the better practice is to divide it carefully, so as to remove both at the same time. Tearing the membrane and crushing the brain substance are thus avoided. In infants and young children this mode of procedure is most necessary, as in them the dura mater is, as a rule, adherent.

25. The ordinary mode of examining the membranes of the brain, and the brain itself, answers well in medico-legal dissections. Effusions of fluid within the skull should always be measured. After the brain is removed, the dura mater ought to be stripped from the base of the skull to facilitate the search for fractures there, which will, of course, indicate external violence. After the removal of the brain, the upper part of the spinal canal should be examined through the foramen magnum before any part of its course be laid open; and search should be particularly made for dislocation or other injury in the region of the atlas and dentata. In cases of fatal fractures of the head, the strength of the bones should be attended to. In cases of extravasation within the head, the state of the coats of the cerebral arteries should be examined.

26. The best mode of opening the spine is, after having finished the examination of the brain, to cut through the integuments from the occiput to the coccyx—to lay the vertebræ thoroughly bare on each side by cutting away the muscles—to make an incision with the saw on each side of the skull, from the postero-inferior angle of the parietal bones into the lateral edge of the occipital hole—to remove the triangular portion of the occipital bone thus detached, and then to cut the rings of the vertebræ on each side with the bone-nippers or spine-knife, beginning with the atlas. In these cases preference should be given to the saw, by which the operation is not only more easily accomplished, but there is no risk of confounding previous fracture with that made in dissecting. Where there is reason to think that the bones are injured, the laying

open of the canal should stop at the distance of two or three vertebræ from the injury, and the injured bones, with two or three adjacent vertebræ on each side, should be removed entire before the examination is extended farther down the spine.

27. The organs of the throat may be examined, either by dividing the lower jaw-bone at the chin, cutting the soft parts close to the inner surface of each half of the bone backwards, and then turning the two segments outwards; or by freely reflecting the skin of the throat, separating the soft parts from the inside of the lower jaw, the knife being carried parallel with and close to the bone, drawing the tongue out below the chin, and then continuing the dissection backwards.

28. The best mode of examining the organs situated in the throat is, after detaching the soft parts from the lower jaw, as advised in Sect. 27, to dissect the soft palate from the bone, and proceeding backwards, to detach the whole soft parts from the base of the skull and vertebræ down to the sternum, leaving them connected with the organs in the chest. Besides the ordinary points to be attended to in this part of the examination, the presence of venereal or other ulcerations is a matter requiring attention in some cases.

29. It is necessary to examine the pharynx and gullet, the larynx, trachea, and its greater ramifications, the lungs, the heart, and the great vessels with particular care, because here are most frequently found the causes of sudden natural death. In examining the heart each auricle and each ventricle ought to be laid open by an independent incision of its parietes; and this should not intersect either any of the valvular openings or the septum cordis.

30. For laying open the chest and abdomen, the most convenient method is to make an incision down the fore part of the neck, chest, and abdomen to the pubes; then cutting from the peritoneum upwards, to dissect back the integuments and muscles of the chest, and examine the abdomen, as in Sect. 22; next, divide the cartilages of the ribs, and, cutting upwards, close under them, to raise the cartilages along with the sternum. In separating the sternum from the clavicles, care must be taken not to wound the subjacent vessels; and this may be avoided by the dissector moving each shoulder so as to show the exact position of the sterno-clavicular joints, and then dividing both joints cautiously. In dividing the cartilages of the ribs, the saw is sometimes necessary. The cartilages should be cut as far from the sternum as possible, to give free space for the subsequent examination.

31. In inspecting the organs in the chest, a cursory examination should be first made by turning them over, ascertaining the nature and measuring the quantity of effused fluids, feeling for fractures of the ribs, tumours, or other diseases, and opening the pericardium to obtain a view of the heart. The most convenient course to pursue next is, without moving the heart from its place, to lay open its several cavities, in order to judge of the quantity and state of the blood in both sides of that organ. For this purpose the following incisions should be made:— The *first*, beginning close to the base, is carried along the right border of the heart directly into the right ventricle towards the apex, care being taken not to cut the septum. This lays open the right ventricle. The *second* incision, opening up the right auricle, begins midway

between the entrances of the venæ cavæ, ending just in front of the base. The *third*, for exposing the left auricle, commences at the left superior pulmonary vein, and ends just in front of the base, close to the coronary vein, care being taken not to wound it. The *fourth*, displaying the left ventricle, commences behind the base, and ends close to the apex. If the blood is in a fluid state, the quantity contained in the right auricle may be materially affected by the head being examined previously, as the blood may have escaped from the heart by the jugular veins. The whole of the organs in the chest—namely, the lungs, heart, and gullet—together with the parts dissected downwards from the throat, should now be removed in one mass, in order to examine them in detail on a table. But previously two ligatures should be applied on the gullet, just above the cardiac orifice of the stomach, and the division made between them.

32. The organs in the abdomen ought to be turned over, like those of the chest, before any one of them is minutely examined, but before the thorax is opened, for the reasons given in Sect. 22. In the subsequent examination, that organ is to be first proceeded with in which there may appear to be disease.

V. Examination in Cases of Wounds and Contusions.

33. In a *post-mortem* examination, the most approved mode of examining these injuries is, if they be situated over great cavities, to expose the successive structures in the manner of an ordinary dissection, observing carefully what injuries have been sustained by the parts successively exposed before they are divided. Wounds ought not to be probed, especially if situated over any of the great cavities. The depth of a wound is best ascertained by careful dissection and exposure of the parts involved; but after this is done, the thickness of the tissues penetrated may be measured by the probe.

34. The seat of the wounds must be described by actual measurement from known points, their figure and nature also carefully noted, and their direction ascertained with exactness.

35. Before altering by incisions the external appearances of injuries, which should never, if possible, be done, care must be taken to consider what weapon might have produced them, and if a particular weapon be suspected, it should be compared with them. The wounded parts should be cut out entire, and carefully preserved.

36. Apparent contusions must be examined by making incisions through them; and the inspectors will note whether there be a swelling or puckering of the skin; whether the substance of the true skin be black through a part or the whole of its thickness; whether there be extravasation below the skin or in the deeper textures, and whether the blood be fluid or coagulated, generally or partially; whether the soft parts below be lacerated, or subjacent bones injured; and whether there be blood in contact with the lacerated surfaces. By these means the question may be settled whether the contusions were inflicted before or after death.

37. In the cases of wounds, too, the signs of vital action must be attended to, especially the retraction of the edges, adhesion of blood to

their surfaces, or the injection of blood into the cellular tissue around, or the presence of the signs or sequelæ of inflammation. Hypostasis must not be mistaken for vascular injection.

38. When large arteries or veins are found divided, care must be taken to corroborate the presumption thus arising by ascertaining, in the subsequent dissection, whether the great vessels, lungs, liver, and membranous viscera of the abdomen be unusually free of blood.

39. In the course of the dissection of wounds, a careful search must be made for foreign bodies in them. When firearms have occasioned them, the examination should not be ended before discovering the bullet, wadding, or other article, if any, lodged in the body ; and whatever is found must be preserved. When the article discharged from firearms, or when any other weapon has passed through and through a part of the body, the two wounds must be carefully distinguished by their respective characters, especially as regards their comparative size, inversion or eversion, smoothness or laceration, of their edges, their roundness or angularity, and the comparative amount of bleeding from each. In gunshot injuries, the presence or absence of marks of gunpowder should be noted.

40. When wounds are situated over any of the great cavities, they ought not to be particularly examined till the cavity is laid open ; and in laying open the cavity, the external incisions should be kept clear of the wounds.

41. When the discoloured state of a portion of the skin is such as to render it doubtful whether it is due to injury or to changes after death, an incision should be made to ascertain whether there is blood effused into the textures, constituting true ecchymosis, or merely gorging of the vessels of the skin, or discoloration from infiltration of the colouring matter of the blood, which takes place in depending parts of a dead body. The term suggillation should be avoided, as it has been used in opposite senses by Continental and British authors. The respective expressions, "discoloration from extravasated blood," and "lividity after death," are preferable.

VI. Examination in Cases of Poisoning.

42. In examining a body in a case of suspected poisoning, the inspectors should begin with the alimentary canal, first tying two ligatures round the gullet, above the cardiac orifice of the stomach, two round its pyloric end, and a third at the sigmoid flexion of the colon, then removing the stomach and entire intestines : next dissecting out the parts in the mouth, throat, neck, and chest in one mass ; and, finally, dissecting the gullet, with the parts about the throat, from the other organs of the chest. The several portions of the alimentary canal may then be examined in succession.

43. Previous to commencing the dissection in cases of supposed poisoning, the inspectors should make such inquiries as may enable them to form an opinion as to the class of poison to which the death may be traceable, and thus to guide them as to the conclusions to be come to from the presence, or it may be the complete absence, of any marked appearance explaining the cause of death.

44. The medical inspectors may afford most important aid to the law officers in investigating the history of cases of supposed poisoning. For this purpose minute inquiry should be made into the symptoms during life, their nature, their precise date, especially in relation to meals or the taking of any suspicious article, their progressive development, and the treatment pursued. It is impossible to be too cautious in collecting such information, and, in particular, great care must be taken to fix the precise date of the first invasion of the symptoms, and the hours of the previous meals. The same care is required in tracing the early history of the case, where the inspector happens to visit the individual before death; and if suspicions should not arise till his attendance has been going on for some time, he ought, subsequently to such suspicions, to review and correct the information gathered at first, especially as to dates. All facts thus obtained should be immediately committed to writing.

45. Besides inspecting the body and ascertaining the history of the case, the inspectors may afford valuable assistance to the law officers in searching for suspicious articles in the house of the deceased. These are—suspected articles of food, drink, or medicine; the vessels in which they have been prepared or afterwards contained; the family stores of the articles with which suspected food, etc., appears to have been made. All such articles must be secured, according to the rules in Sect. 13, for preserving their identity. In this examination the body-clothes, bed-clothes, floor, and hearth should not be neglected, as they may present traces of vomited matter, acids spurted out or spilled, and the like.

46. When a medical man is called to a case during life, where poisoning is suspected, he ought as soon as possible to follow the instructions laid down for securing articles in which poison may have been administered.

47. In the same circumstances, it is his duty to observe the conduct of any suspected individual, were it for no other reason than to prevent the remains of poisoned articles from being put out of the way, and to protect his patient against further attempts.

48. The whole organs of the abdomen must be surveyed, and particularly the stomach and whole tract of the intestines, the liver, spleen, and kidneys, the bladder; and in the female, the uterus and its appendages. The intestines should in general be split up throughout their whole length; and it should be remembered that the most frequent seat of natural disease of their mucous membrane is in the neighbourhood of the ileo-cæcal valve, and that, next to the stomach, the parts most generally presenting appearances in cases of poisoning are the duodenum, upper part of jejunum, lower part of ileum, and rectum.

49. In cases where the possibility of poisoning must be kept in view, and where matters may require to be procured for chemical analysis, it is essential to be sure that all instruments, vessels, and bladders used are scrupulously clean.

50. When any unusual odour is perceived, either in the blood in the course of making the dissection, or in the stomach when opened, it ought to be carefully observed, and if possible identified by all the medical men present. In this way alcohol, opium, prussic acid, oil of bitter almonds, and other odorous poisons may be recognised. The smell of

the contents of the stomach ought always to be noted whenever it is opened, as the smell often alters rapidly.

51. The stomach and intestines should be taken out entire, and their contents emptied into separate bottles. If the stomach or part of the intestines present any remarkable appearance, examination may be reserved, if convenient, till a future opportunity ; but in every circumstance it must be preserved and carried away, as it may itself be an important article for analysis. The throat and gullet may be examined at once, and preserved with their contents, which, if abundant, may be kept apart in a bottle. In addition to the alimentary canal and its various contents, portions of the solid organs of the body ought to be secured for analysis. The most important are the liver, spleen, and kidneys. A part of the liver, at least a fourth part, should be secured in every case of supposed poisoning ; and in cases where the fatal illness has been of long duration, and therefore only traces of the poison may remain in the body, the whole of the liver, the spleen, and both kidneys should be secured. A portion of the blood, especially when the odour of any volatile poison is perceived, should be at once put into a bottle, closed by a good cork or stopper.

52. No person ought to undertake an analysis in a case of suspected poisoning unless he be either familiar with chemical researches, or have previously analysed with success a mixture of organic substances, containing a small proportion of the poison suspected.

53. All persons undertaking an analysis should bear in mind that the opinion of some other person practised in toxicological researches may be required ; and they should therefore take care, when practicable, to use only a portion of the several articles preserved for analysis. The identity of the subjects for analysis must be secured by the rules in Sect. 13.

VII. Examination in Cases of Suffocation.

54. In cases of suspected drowning, the inspectors will observe particularly whether grass, mud, or other objects be clutched by the hands, or contained under the nails ; whether the tongue be protruded or not between the teeth ; state of the penis ; whether any fluid, froth, or foreign substances be contained in the mouth, nostrils, trachea, or bronchial ramifications ; whether the stomach contains much water ; whether the blood in the great vessels be fluid. Careful pressure should be made upon the lungs ; any fluid contained in them is thus forced into the bronchial tubes and trachea, and its nature observed. When water with particles of vegetable matter or mud is found within the body, these must be compared with what may exist in the water in which the body was discovered, and should be preserved for further scientific investigation, if requisite. Marks of injuries must be compared diligently with objects both in the water and on the banks near it, and especial attention given to the question—whether any observed injuries had been sustained by the body before or after death.

55. In cases of suspected death by hanging, strangling, or smothering, it is important to attend particularly to the state of the face as to lividity, compared with the rest of the body ; the state of the

conjunctiva of the eyes as to vascularity; of the tongue as to position; of the throat, chin, and lips, as to marks of the nails, scratches, ruffling of the scarf-skin, or small contusions: the state of the blood as to colour and fluidity: the state of the heart as regards the amount of blood in its several cavities: the state of the trunk and branches of the vena cava in the abdomen as regards distension with blood; and the state of the lungs as regards congestion, rupture of any of the air cells, and small ecchymoses under the pleura, or the pericardium. The mark of a cord or other ligature round the neck must be attentively examined; and here it requires to be mentioned that the mark is often not distinct till seven or eight hours after death, and that it is seldom a dark livid mark, as is very commonly supposed, but a pale greenish-brown streak, presenting no ecchymosis, but the thinnest possible line of bright redness at each edge, where it is conterminous with the sound skin. Nevertheless, effusions of blood and lacerations should be also looked for under and around the mark, in the skin, cellular tissue, muscles, cartilages, and lining membrane of the larynx and trachea. Accessory injuries on other parts of the body, more especially on the chest, back, and arms, must also be looked for, as likewise the appearance of blood having flowed from the nostrils or ears, and the discharges of fæces, urine, or semen. In cases where death may be due to the emanations from burning fuel or other poisonous vapours, a small phial should be filled with the fresh blood, and securely corked for further investigation, if requisite.

VIII. Examination in Cases of Burning.

56. In supposed death by burning, the skin at the edge of the burns should be carefully examined for redness, or the appearance of vesicles containing fluids.

IX. Examination in Cases of Criminal Abortion.

57. In suspected criminal abortion, when the woman survives, the chief points for inquiry are:—The proofs of recent delivery, the ascertaining of facts tending to show that she has been subjected to manœuvres with instruments, and the occurrence of symptoms traceable to the action of any of the drugs reputed as capable of causing abortion.

When the woman has died, the points requiring special attention at the dissection are:—The state of the womb, as regards its size and the condition of its lining membrane, in reference to the probable period of delivery: the condition of the intestinal canal, in reference to the action of irritant drugs; of the mucous membrane of the bladder, in reference to the action of cantharides; close inspection of the womb and vagina, in reference to mechanical injuries, especially punctured wounds; and any appearances that the death may have been caused by inflammation in the organs of the pelvis, or by bleeding from the wound.

X. Examination in Cases of Infanticide.

58. In cases of suspected infanticide, certain specialities must be borne in mind. The cavity of the head should be laid open with a pair

of scissors. In opening the abdomen, the navel should be avoided, so that the state of the vessels of the navel-string may be examined correctly. This is done by carrying two incisions from the ensiform cartilage to each of the anterior superior spines of the ilia, and by deflecting downwards the triangular flap thus formed.

59. The inquiry in cases of infanticide should be conducted with reference to the five following distinct questions :—(1) The probable degree of maturity of the child ? (2) How long it has been dead ? (3) Whether it died before, during, or after delivery, and how long after ? (4) Whether death arose from natural causes, neglect, or violence ? and (5) Whether a suspected female be the mother of the child ?

60. The points to be attended to for ascertaining the probable degree of maturity of the child are :—The general appearance and development, the state of the skin, its secretions, and its appendages ; the hair and nails ; the presence or absence of the pupillary membrane ; the length and weight of the whole body ; whether the navel corresponds or not with the middle of the length of the body ; the situation of the meconium in the intestines ; the size of the testicles in the case of males, and in either sex the size of the point of ossification in the lower epiphysis of the thigh-bone. This is easily observed by making an incision across the front of the knee into the joint, pushing the end of the thigh-bone through the cut, slicing off the cartilaginous texture carefully until a coloured point is observed in the section, and then, by successive very fine slices, ascertaining the greatest diameter of the bony nucleus. This does not exist previous to the thirty-sixth week of gestation, and in a mature child is about one-fourth of an inch in diameter. Has the infant been washed ? Absence or presence of vernix caseosa. Nature and character of the wrappings, if any, found on the child.

61. The points of chief importance in reference to the period which has elapsed after death are those specified in the last clause of Sect. 17—it being borne in mind that the bodies of infants are often concealed in ash-pits and dunghills, and that in these circumstances putrefaction is very rapid.

62. The circumstances which indicate whether the child died before, during, or after parturition, and how long after it, are the signs of its having undergone putrefaction within the womb ; the marks on the crown, feet, buttocks, shoulders, etc., indicating presumptively the kind of labour, and whether it was likely to have proved fatal to the child ; the state of the lungs, heart, and great vessels, showing whether or not it had breathed ; the nature of the contents of the stomach and of the intestines ; the presence of foreign matters in the windpipe ; the state of the umbilical cord, or of the navel itself, if the cord be detached.

63. In order to examine properly the state of the lungs, heart, and great vessels, with a view to determine whether or not the child had breathed, the inspection should be made in the following order :—Attend, first, to the situation of the lungs ; how far they rise along the sides of the heart ; to their colour and texture ; whether they crepitate or not. Then secure a ligature round the great vessels at the root of the neck, and another round the vena cava above the diaphragm. Cut both sets of vessels beyond the ligatures, and remove the heart and

lungs in one mass, which must be weighed and put into water, to ascertain whether the lungs, with the heart attached, sink or swim. In the next place, put a ligature round the pulmonary vessels, close to the lungs, and cut away the heart by an incision between it and the ligature. Lastly, ascertain the weight of the lungs; whether they sink or swim in water; whether blood issues freely or sparingly when they are cut into; whether any fragments swim in the instances where the entire lungs sink; and in every instance of buoyancy, whether fragments of them continue to swim after being well squeezed in a cloth.

64. The general question to be considered in relation to the cause of death is, whether the appearances are such as to be traceable to the act of parturition, or whether they indicate some form of violent death. The directions given in Divisions V., VI., and VII. apply to infants as well as adults; but the following points are specially to be noticed in cases of supposed infanticide:—

In relation to wounds and contusions, the possibility of minute punctured wounds of the brain or other vital organs; in reference to injuries of the head, the effusion of blood under the scalp, not in the situation where it could have been produced during labour, or fracture of the bones not producible by compression of the head during labour, and not connected with defective ossification of the skull; in reference to the allegation that the head was injured by the child suddenly dropping from the mother, when not recumbent, the presence of sand or other foreign matters on the contused scalp, and the existence of more than one injury of the head; in relation to suffocation, the external and internal signs of this form of death—marks of compression of the mouth, and nose, and throat, and the presence of foreign matters in the mouth and throat, air passages, gullet, or stomach, especially if the body be found in contact with similar substances; in reference to bleeding from the navel-string, a bloodless state of the body, without any wound to account for it; in reference to poisons, most commonly narcotics, the absence of any of the above appearances, with an otherwise healthy state of the body; in reference to starvation and exposure, emaciation of the body, absence of food from the stomach, and an empty, contracted condition of the intestines; in reference to the possibility of the child having been suddenly expelled, and having fallen on the floor or into privies, etc., the state of the navel-string is to be noted — whether long or short, whether remaining attached to the child and connected with the after-birth, indicating rapid labour, or, if divided, whether it had been cut or torn across. Nature of the ligature used, if any.

65. The circumstances noticed in Sects. 60, 61, 62, 63, 64, compared with the signs of recent delivery in the female, will lead to the decision of the question whether the suspected female be the mother of the child. These circumstances may be shortly recapitulated as being the signs of the degree of maturity of the child—the signs on the body of the kind of labour, the signs which indicate the date of its death, and the interval which elapsed both between its birth and death, and between its death and the inspection.

EXHUMATIONS.

It becomes necessary sometimes to exhume the bodies of persons who have been buried. The cases which generally call for this always unpleasant, and in most cases disgusting pro-

ceeding, are those where a suspicion of poisoning or violence has arisen some little time after the burial of the supposed victim. Or the necessity may arise to show that the body buried is that of a person whose death it is absolutely necessary to prove. In the case of Livingstone, though this can scarcely be called a case of exhumation, yet an examination some months after death of the arm of the corpse alleged to be that of Livingstone, proved the existence of a badly united fracture which the deceased was known to have had.

In conducting the exhumation, it is necessary that the medical experts should be present to see the body removed from the coffin, and also any person or persons who may be in a position to speak as to the identity of the corpse—as, for instance, those who dressed it and prepared it for burial. The person who made the coffin may also be of assistance to speak as to its identity. As soon as the medical men are armed with the proper authority, no time should be lost in order to get the body as fresh as possible, and at once prove or disprove the accusation of the crime, which, in the case of innocent persons, cannot be too quickly removed. The best time to take up the body, if in the summer, is early in the morning; and, in all cases, the examination, if possible, should be made during daylight. Disinfectants may be sprinkled on the grass, on the coffin, and around but not on the body when lying on the table during the inspection. Everything necessary for making a medical inspection should be taken, and also a table on which to place the body. A pail containing a solution of chloride of lime, for the inspectors to wash their hands, should be close at hand. And it is as well to expose the body for a short time to the air before beginning the inspection. There is seldom any risk to health in removing a single body, yet certain precautions are necessary; thus it is as well to stand on the windward side of the corpse. Vaults should not be entered as soon as they are opened, but time allowed for their ventilation. No *post-mortem* should ever be conducted on an empty stomach. Carefully note the amount of preservation of the coffin, and, if broken, if any of the surrounding earth is in contact with the body. This precaution is necessary in cases of suspected mineral poisoning (as in arsenic, etc.), and it is as well also to save one or two pounds of the earth immediately above the coffin for analysis. The

body may then be examined externally, any hair left on head or face preserved for identification; and then an inspection of all the cavities made, the contents of the stomach and bowels being placed in dry earthenware jars or glass bottles, corked and capped with thin indiarubber skin, and so tied and sealed that the string must be cut or the seals broken in order to open them. The ends of the string should be sealed in the presence of the authorities. In the examination, the instructions previously given should be carefully followed. All injured or diseased parts should be removed and preserved whenever this is practicable. Soft parts not intended for analyses may be preserved in a concentrated solution of salt.

Beyond what Period is it useless to Exhume a Corpse?—There is no scientific limit, for even the bones may show that violence has been used, or may point to the identity of a corpse, as in the case of Livingstone just mentioned. Pregnancy may be detected. The medical inspectors must proceed with the inspection unless they can positively say that the progress of decay is such as to render the examination nugatory in relation to its special objects. Casper mentions the case of a man whose body was three times exhumed for different purposes. In Scotland the law imposes a limit of twenty years, but in England the law is silent on the point; in France a limit of ten years from the date of the supposed crime; and in Germany, the limit is thirty years, if the offence is that punishable with death, the time varying from three to thirty years with the nature of the crime.

EXAMINATION OF LOCALITIES.

This is generally done by the police, but it may sometimes be undertaken with advantage by experts, and it is desirable that the medical inspectors should have an opportunity of viewing the body before it is undressed, or moved from the spot where it was first found. If the body has been previously removed or meddled with, they ought to inform themselves accurately as to its original position, for in many cases it is material that they personally visit the place where it was first seen, and they should inquire minutely into all the particulars connected with the removal of it. Important articles of evidence are often overlooked, owing to the absence of a medical man, to whom alone their importance would have been apparent.

There is considerable difference of opinion as to the size of a footprint on the ground, Mascar of Belgium asserting that it is *smaller* than the foot that made it, Caussè, on the contrary, that is usually *larger*. It should be borne in mind that the size of the footprint varies in running, walking, and standing, being smallest in running and largest when the individual is standing. This fact may account for the difference of opinion of the two observers just mentioned. A mark in the footprint showing that the sole of the boot had been patched, or in the case of the naked foot that there was some deformity of the toes, would of necessity be important. The mark of the naked foot smeared with blood has, in several cases, led to the identification of the culprit. Casts of footprints may be taken with wax, or perhaps better, with equal parts of Roman cement, fine sand, and plaster of Paris. Sprinkle this mixture over the footprint, and then place a cloth over it. Gradually moisten the cloth, so that the water may slowly percolate, until the mixture is quite moist ; now lift the cloth, and allow the cement to harden. Another method suggested by M. Hougolin is as follows :—The footprint or the mark is gradually heated by holding over it a pan containing burning charcoal, and then powdered stearic acid or paraffin is sprinkled into the footprint so heated, and allowed to cool. From the mould so taken, a plaster of Paris cast can be made. The stearic acid may be powdered by dissolving it in spirit and then pouring the solution into water. When the footprints are in snow a cast of them may be taken in gelatine.

CHAPTER V.

ASSAULTS, HOMICIDE, AND WOUNDS

Assault.—Every act of attack upon the person of another is an assault in law, whether it injure or not; nor is it necessary that the act done take effect. Spitting on any one is an assault. No provocation by word, whether written or spoken, can justify an assault, though it may mitigate the offence. If a medical man unnecessarily strip a female patient naked, under pretence that he cannot otherwise judge of her illness, it is an assault if he himself take off her clothes (R. *v.* Rosinski, 1 Mood C.C. 12). So, where a medical man had connection with a girl fourteen years of age, under the pretence that he was thereby treating her medically for the complaint for which he was attending her, she making no resistance solely from the *bona fide* belief that such was the case, this was held to be certainly an assault, and probably a rape (R. *v.* Case, 1 Den. 580; 19 L.J. [M.C.] 174). By a recent Act of Parliament such an act is now held to constitute a rape.

Battery.—This includes beating or wounding. A touch of the finger, however slight, is included under this term.

Homicide.—In Scotch law homicide is held to be committed only where a distinctly self-existent human life has been destroyed. Destruction of an unborn child, however short a time before delivery, may be criminal, but is not homicidal. In the same country criminal homicide is divided into two classes:—

(1) Murder. (2) Culpable Homicide.

1. *Murder* is constituted in law by any wilful act causing the destruction of human life, whether plainly intended to kill, or displaying such utter and wicked recklessness as to imply

a disposition depraved enough to be wholly regardless of the consequences. Murder may be the result of personal violence, poison, or by the committal of some other serious crime, as where any one causes the death of a woman in the attempt to procure criminal abortion, rape, or by the exposure of an infant which results in its death. The use of weapons is not essential.

2. *Culpable Homicide.*—The name applied in law to cases where the death of a person is caused or materially accelerated by improper conduct of another, and where the guilt does not come up to the crime of murder:—

(*a*) Intentional killing of another in circumstances implying neither murder on the one hand, nor justifiable homicide on the other—*e.g.* if a person exceed moderation in retaliation for an injury, or kill another when the danger to which he was exposed is passed.

Every charge of murder is held to include a charge of culpable homicide, and the jury, if they see cause, may find that culpable homicide only has been committed.

(*b*) Homicide, by doing of any unlawful, or any rash and careless act, from which death results, though not foreseen as probable—*e.g.* using firearms in a public street, etc.

(*c*) Homicide, resulting from negligence or rashness in the performance of a lawful duty—*e.g.* a signalman on a railway forgetting to alter the points, and thus causing a collision and loss of life. In England this would amount to manslaughter.

Justifiable Homicide.—Self-defence; hanging a prisoner properly sentenced to death; killing another to prevent murder, if prevention can avail in no other way. In self-defence, the person killing must be in *reasonable dread* of death at the hand of his adversary.

In England there is—1. Murder; 2. Manslaughter; 3. Justifiable Homicide.

Murder, according to Lord Coke (3 Inst. 47), is constituted "where a person of sound memory and discretion unlawfully killeth any reasonable creature in being, and under the King's peace, with malice aforethought, either expressed or implied."

In England the killing must be committed with malice aforethought. Malice may be expressed or implied.

In Scotland malice aforethought is not necessary (5 Irv. 525, and 40 S.J. 92, and 5 S.L.R. 20).

The law in both countries appears to differ more in terms than in practice. In England, if an injured party live for one year and a day, and then die, death is not attributed to the

injury; but in Scotland, although no definite time is fixed, yet no case would I believe be entertained at any lengthened period after the commission of a homicidal act. The longest interval, according to Taylor, at which conviction has taken place from indirectly fatal consequences was *nine months*.

In the United States, as a rule, the crime of murder admits of two degrees: in the *first*, where the act is intentional or is the result of an attempt at burglary, rape, arson, or by poison; otherwise the crime falls under the *second* degree.

Responsibility of Assailants.—It is held in law that every man is responsible for consequences of his acts. Lord Hale observes:—"It is sufficient to constitute murder, that the party dies of the wound given by the prisoner, although the wound was not originally mortal, but became so in consequence of negligence or unskilful treatment, but it is otherwise where death arises not from the wound, but from unskilful applications or operations used for the purpose of curing it." This is a fine distinction, and it has been held that to exonerate the assailant the treatment must be *grossly improper*. If the wounds were not fatal, but by unskilful treatment death ensued, the assailant is not culpable. The refusal of the injured party to undergo treatment does not excuse the assailant, as in R. *v.* Wall, in which case the Lord Chief Baron charged the jury that no man was authorised to place another in so perilous a predicament as to make the preservation of his life depend on his own prudence. Even an abnormal position of organs or an unhealthy state of the body is no excuse; the most their presence can do is to reduce the capital offence to manslaughter, for the Chief Baron remarked in the case of Bennet *v.* Gedley that a man was not bound to have his body in so sound and healthy a state as to warrant an unauthorised assault upon him. In all cases the mitigation of the offence will depend on a careful consideration of the entire circumstances of the case.

WOUNDS.

Legal Definition.—According to the statute (24 and 25 Vict. c. 100, sec. 18), the word "wound" includes incised, punctured, lacerated, contused, and gunshot wounds. But to constitute a wound within the meaning of the statute, the *whole skin*, not the mere *cuticle*, or upper skin, must be divided

(R. *v.* M'Laughlin, 8 C. & P. 635). But a division of the *internal* skin, *e.g.* within the cheek or lip, is sufficient to constitute a wound within the statute (R. *v.* Warman, 1 Den. C.C. 183). If the skin be broken, the nature of the instrument with which the injury is inflicted is immaterial, for the present statute extends to wounding, etc., "*by any means whatsoever.*" A wound from a kick with a boot is within the statute (R. *v.* Briggs, 1 Mood C.C. 318). Injuries, burns, and scalds—which, in accordance with the above definition of a wound, are not wounds—are provided for under the clause, "or cause any grievous bodily harm to any person."

Casper defines "an injury" to be "every alteration of the structure or function of any part of the body produced by any external cause." Taylor proposed the following as the best definition which can be given to the word "wound," whether in a medical or legal sense, viz. that it is "a breach of continuity in the structures of the body, whether external or internal, suddenly occasioned by mechanical violence." This would include dislocations, fractures, either simple or compound, injury to the skin or mucous membrane, and to internal organs. Burns and injuries due to the action of corrosives are excluded from the category of wounds.

Concerning Wounds in general.—Great care must be taken to ascertain the exact site and course of the injury on the body, as this precaution will greatly assist in answering the questions:—*Is the wound dangerous to life? Does it cause grievous bodily harm? Is it suicidal, that is, inflicted by the person on himself; or homicidal, inflicted by another?* The solution of the question of the dangerous character of the wound is left to the professional knowledge of the witness, who may be required to state his reasons for considering the wound dangerous to life. His mere assertion will not be accepted. "The safest course," says Elwell, "for the witness, in regard to all these questions, is to give a true and plain account of the wound, describing it minutely, and the probable consequences that may attend it." As a general rule, only those wounds in which the danger to life is *imminent* should be stated as dangerous to life. Compound fracture of the bones of the cranium, injury to any large arterial trunk, or to any of the internal organs, may be considered as "dangerous to life"; but where the danger is more remote, as in the probable

supervention of tetanus, erysipelas, etc., the medical opinion must be more guarded. But the medical witness should always bear in mind that death may follow the slightest injury. A case is recorded of death in forty-eight hours after extraction of a tooth. The contrary also holds good, for the most fearful injuries have been followed with recovery.

The following suggestions may help the practitioner in the formation of his opinion as to the probable danger of a wound :

1. The extent of the injury. 2. The character of the instrument used in the infliction of the wound. 3. The violence suffered by the parts. 4. The size and importance of the blood-vessels and nerves injured. 5. Is the wound healing or likely to heal well, and is the constitutional disturbance severe or slight? 6. Age of the sufferer. 7. Is there any constitutional taint likely to render even a slight wound more severe, or even dangerous to life? 8. Has the previous medical treatment been skilful or otherwise?

Should the injured party be found dead, a careful *post-mortem* examination will alone determine the probable part the injury bore in the production of the fatal result. Wounds may prove fatal

1. *Directly* (*a*) Haemorrhage ; (*b*) Shock ; (*c*) Mechanical injury.

2. *Indirectly*—(*a*) Erysipelas ; (*b*) Tetanus ; (*c*) Pyaemia or Septicæmia ; (*d*) Gangrene ; (*e*) Surgical operations.

3. *Malum Regimen.* (*a*) On the part of the patient ; (*b*) on the part of the medical attendant.

As the condition of a fracture of the bone of a limb may become a question of considerable importance in medico-legal investigations, the following brief account of the process of repair in fractures is given :—

From the First to the Third Day.—The period of inflammation and exudation. Ordinary signs of inflammation and laceration of the parts. Blood will be found extravasated round the fracture, also in the medullary canal mixed up with the fat.

From the Third to the Fourteenth Day.—Gradual subsidence of inflammatory action and growth of the soft provisional callus from the periosteum and surrounding structures, and internally in the medulla, forming a fusiform mass holding the broken ends of the bones together with some degree of firmness. This becomes firmer and almost cartilaginous in density. When the bones are kept immovable, or are impacted, the provisional callus may not be formed. In the case of the ribs the provisional callus is always formed, and Dupuytren's "ring of provisional callus" is constant. This may also occur in fractures of the clavicle.

From the Fourteenth Day to the Fifth Week.—Ossification of the pro

visional callus. The bone is first soft and spongy till the conversion of the soft callus is complete.

From the Fifth Week to some Months after the Injury.—Complete bony union of the fracture and absorption of the provisional callus.

Although the blood clot completely disappears from the immediate neighbourhood of the fracture at an early period, yet layers of dark coagulum may often be found beneath the superficial fascia for four weeks or more after the accident (Erichsen).

It may be of importance to remember this in medico-legal inquiries. The presence or absence of the signs of vital reaction will help to distinguish fractures caused before or after death.

Injuries to the Head.—These may be either *external*, affecting the integuments; or *internal*, affecting the brain substance, etc. In the latter, as a rule, there are signs of external violence. An ecchymosed tumour of the scalp may impart a *sensation of crepitation* to the finger, and may thus be mistaken for a fracture of the skull. The tumour may also pulsate if any large vessel be near it, giving one the idea that the pulsations are due to the movements of the brain. A large wound without fracture points to a more or less oblique blow, a small wound to direct violence. A blow with a heavy blunt weapon may make a clean incised wound, and often in these cases the seat of the bruise does not correspond with the centre of the cut. Dr. Ogston mentions the case of a young lady where a cricket ball inflicted a wound across the forehead, immediately above, and of the length of, one of the eyebrows, which he could not distinguish from a wound by a cutting instrument. All injuries to the head are more or less severe and dangerous, and great care is required in forming a prognosis with regard to the ultimate effect of an injury to the head. Inflammation of the brain does not, as a rule, supervene for about a week after the accident, and patients should not be considered safe from danger till two or three weeks after. Be it remembered also that in some cases the inflammatory action may proceed insidiously for some months without giving any distinct evidence of its presence till close upon a fatal termination. Scalp wounds are dangerous, from erysipelas, etc. They should be examined as to their extent, form, depth, and position.

Concussion of the brain may arise from falls on the nates, or from blows on the head. The face becomes pale, the pupils contracted, the pulse weak and small, the extremities cold, the respiration scarcely perceptible, and the sphincters relaxed. The tendency to death is from syncope. Reaction may then occur: the pulse quickens; the skin is hot and dry; there is great confusion of thought, from which the patient ultimately recovers; vomiting is present in most cases. Concussion often passes into compression, due to haemorrhage from the lacerated cerebral vessels. Concussion and compression differ in this: in the former, the effects are instantaneous; in the latter, a short time elapses before the symptoms make their appearance; and these become more and more marked, whereas in concussion they gradually pass off. It is often a difficult matter to distinguish the effects of compression from those common to drunkenness or narcotic poisoning. The odour of the breath and the history of the case will assist in forming an opinion. Concussion of the brain may prove fatal without either fracture of the skull, effusion of blood within the cranium, or any other change being observed on dissection, death being caused by the shock given to the whole nervous organ, which, being unrelieved, speedily lapses into annihilation of function (Watson and Travers).

The symptoms of compression—a full, strong, and often irregular pulse; normal heat of surface; muscular relaxation; dilatation of the pupils; stertorous breathing, and paralysis—are not unfrequently retarded, and this consideration should render the opinion very guarded. Bryant records a case (*Surgery*, vol. i. p. 216) in which a man was thrown out of a gig on to his head. After a short period of insensibility he walked for half an hour, and then gradually again became insensible, and ultimately died. A large clot was found over the left cerebral hemisphere, the blood evidently having flowed from the middle meningeal artery. The short period of insensibility probably arrested the flow of blood from the artery, which recurred on the sufferer walking. The structural form of the cranium may have much to do with the danger to be expected from blows—some skulls being thinner than others—and in a few rare instances the fontanelles may not have become ossified during life.

The possibility of an unhealthy condition—atheroma—of

the arteries of the brain, or of disease of the heart, must be taken into consideration before venturing an opinion as to the tendency or ultimate cause of death.

It may be stated that the patient died of apoplexy. Apoplexy is a disease of old age, and seldom occurs in the young, although it is just possible it *might* occur. The arteries should, in every case, be examined for the presence or absence of disease. When violence is used, the effusion of blood is, as a general rule, on *the surface* of the brain; but two cases are given by Dr. Abercrombie of spontaneous bursting of a blood-vessel within the head, followed by effusion of blood *upon the surface* of the brain. "An external injury, coexisting with an extravasation of blood into the cerebral substance, does not necessarily imply cause and effect. The previous condition of the brain, or the outpouring of blood from diseased vessels, may, in fact, have been the cause of the accident" (Hewett). When, however, blood is found effused on the surface of the brain, especially between the dura mater and the skull, either beneath or opposite to an external wound, we may reasonably infer that the hæmorrhage is due to a direct blow. Hæmorrhage so severe as to produce dangerous pressure on the brain, as a rule, comes from a rupture of the middle meningeal artery (Abernethy, Brodie).

Husband relates a case in the Edinburgh Infirmary in which there was a large clot over the left frontal lobes, accompanied with aphasia and right hemiplegia, with no rupture of the middle meningeal artery, or any signs of external injury. The man had just left the cells on a charge of drunkenness. The source of the hæmorrhage was not clearly made out, but it seemed to be due to the rupture of an artery in a pachymeningitic patch. Blood may be found in the cavity of the arachnoid in the great majority of severe injuries to the head, and even in trifling cases where least expected. The effused blood may, after a time, become changed, and form a false membrane on the *parietal* arachnoid, seldom on the *visceral* surface. Blood cysts may even be formed, in the course of time, having all the appearances of a serous membrane. The blood may spread to parts remote from the seat of injury, and the extravasation does not always occur at the exact spot of the application of the blow, but often at a spot directly opposite. Two extravasations may be the result of one blow.

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Fits of passion have been pleaded as a cause of apoplexy, but this cause is rare. Fracture of the cranial bones may be due to counter-stroke—*contre-coup*—or to falls on the nates, etc. Fractures of the skull are divided into two groups (KÖRBER): (1) those produced by *bilateral* compression of the skull; and (2) those resulting from violence applied to *one side* only. *In both groups the line of fracture runs parallel with the axis of compression.* Fissures of the base from bilateral compression of the skull are always transverse. Punctured wounds of the cranium are always dangerous, but the patient may survive many days. Husband was once called in to see a boy shortly after he had been kicked by a pony in the region of the left temple, and although a small portion of brain substance was squeezed out through the wound, the boy recovered without a bad symptom. Dr. Bigelow, Professor of Surgery in Harvard University, U.S.A., relates a case in which an iron bar, weighing thirteen and a quarter pounds, three feet seven inches in length, and one inch thick, was driven through the head, followed by recovery, the patient only losing the use of the injured eye.

For the detection of brain substance on weapons the microscope is alone reliable, and then only the cellular portion of the brain is of any use.

Injuries to the spinal cord may cause immediate death; cases, however, occur of life being prolonged for some days, or even longer, after injury to the cord. The symptoms are progressive paraplegia and paralysis of the bladder and rectum, ending in death. Spicula of bone in the cord, dislocation of the vertebræ, or extravasation of blood in the membranes of the cord, may be found after death. The presence of blood upon the spinal cord is not necessarily the result of violence, as Dr. Abercrombie has shown that hæmorrhage may take place spontaneously. The spine should be examined in all fatal cases of supposed injury. Concussion of the spinal cord is a fertile source of differences of opinion in railway cases. In no case should a hasty decision be given as to the probable future result to the patient from the injury.

Wounds of the *face* are not generally dangerous, unless they penetrate the brain.

Wounds of the *throat* are more or less dangerous, due to the possibility of severe hæmorrhage, emphysema, and bronchitis.

Wounds of the *chest* are dangerous, on account of the amount of the hæmorrhage which may take place, and the importance of the organs which may be injured. Death may result more from the mechanical action of the blood effused than from the depressing effect of the quantity evacuated. A fracture of the ribs may give rise to injury of the lung substance or to inflammation of its coverings. The ventricles of the heart may be pierced, and yet life may be prolonged for one or two months, permitting of considerable locomotion during that period (Briand et Chaudé, *Med. Leg.* vol. i. p. 511). It is often difficult to make out the direction of the wound, as the lungs change their position during respiration.

Wounds of the *abdomen*, penetrating the intestines, although not necessarily fatal, may cause death from peritonitis, due to the escape of the intestinal fluids. Hernia may also follow wounds of the abdomen. Rupture of the liver is not of infrequent occurrence, and may occur without any external sign of the injury. The rupture is, as a rule, longitudinal, transverse lacerations being rare. The cœliac plexus may be much damaged by a blow or kick on the stomach, especially if this organ be distended with food, and death may result, without leaving any trace of the injury externally or internally. The bladder may be ruptured and death result from extravasated urine. Coagulable lymph, the effect of a wound of a serous membrane, may be thrown out in twelve hours or less.

Injuries to the abdomen may cause death by—

1. Shock; without lesion of the internal organs, inflammation, or external signs of injury.
2. Hæmorrhage.
3. Lesion of the internal organs, but without inflammation. Death in these cases seems to be due to depression of the nervous system due to the intense pain following these injuries.
4. By inflammation without lesion of internal organs.
5. Inflammation from lesion of internal organs.
6. Destruction of the natural functions of the organs, and, as a result, malnutrition of the body.

Except in the first case, when death is instantaneous, wounds of the abdomen are not as a rule immediately fatal.

Wounds of the *genital organs* of the female may cause fatal hæmorrhage, which takes place from the plexus of veins which,

in these parts, are devoid of valves. A kick from behind whilst the woman is stooping or kneeling may rupture the labial vessels and death supervene.

An important question here arises before we consider the characters of the several kinds of wounds. Have the wounds found on the body been produced during life or after death? The answer is beset with difficulties, and considerable caution will be necessary, but tables will be given under the different kinds of wounds to assist the diagnosis. Signs of vital reaction are important, as showing the *ante-mortem* infliction of the wound; but these may, to some extent, be removed by the action of water, as in cases where the body is found in a pond. Under these circumstances the evident signs of drowning—water in the stomach, etc.—will assist the diagnosis. The presence of putrefaction also greatly obscures the diagnosis. The presence of coagulated blood between the edges of the wound is not a trustworthy indication of the *ante-mortem* infliction of the wound, as experiment has shown that as long as the body remains warm coagulation may take place. Coagulation even in contused wounds, effected before death, may be retarded from various unknown causes—disease, *e.g.* scurvy; mode of death, *e.g.* asphyxia. The amount of hæmorrhage on or around the body is, other things being equal, a safe criterion as to the time when the wound was inflicted. A considerable amount of arterial blood points to *ante-mortem* injury; the presence of venous blood to *post-mortem* injury.

Duties of a Medical Man when called to examine a Wounded Person.—The surgeon should at once visit the wounded party, and proceed to examine the injury, for if this be done before swelling occurs, he will be better able to form an opinion of its nature, extent, and severity. If the wound has been dressed, he should, if possible, obtain the attendance of the person who applied the dressings, and who would be able to describe their nature, and the dangers to be avoided in their removal, should that be deemed necessary. In no case should a surgeon remove the dressings applied by a professional brother without his presence and assistance. The condition of the injured party should be carefully noted, and a minute description of the wound written down at the time. The statements of the bystanders are also useful, and should be noted.

Is the Wound Suicidal or Homicidal?—In cases of suicide,

punctured, incised, and gunshot wounds are more frequently present, seldom contused wounds, unless the person threw himself from a height. Very large wounds are seldom suicidal. It is important to note the direction of a wound, in order to show whether it was caused by a fall on the weapon or not. Wounds made by suicides are generally over vital parts, and a multiplicity of wounds does not point to suicide, except in maniacs, or in very old people where the skin hangs in folds about the neck. Gunshot wounds, when suicidal, are generally found over the region of the heart, temple, or in the mouth. Presence of scorching and powder-marks is important, as pointing to the probable distance at which the firearm was discharged; but their absence is no proof that the weapon was not discharged close to the body. The presence of the weapon close to the body affords a presumption as to the possibility of suicide—its absence, the probability of homicide; but the weapon may be stolen from the side of the suicide. The hands should be examined for marks suggesting the probability of suicide; contusion or abrasion of the fingers from the recoil of the pistol held unsteadily. It may be suggested that the weapon was placed in the hand by the murderer, and that contraction, the result of the *rigor mortis*, had retained it. This is a fallacy, as it has been proved that, even when the weapon has been placed in the hand prior to the accession of the *rigor mortis*, and there kept by bandages, it can be removed with ease. This is not the case, however, when the retention of the weapon is due to spasm immediately preceding death. It is strong evidence in favour of suicide if the gun or pistol have burst by the explosion, as suicides have a predilection for overloading the weapon employed. The oldness, uselessness, or the novelty—old gun-barrel—of the weapon used, points also to suicide.

Pretended Assault.—How may wounds, alleged to have been the result of an assault, be shown to have been self-inflicted?

By considering—

1. *The Character of the Wounds.*—In these cases the wounds are generally slight, and may consist in a series of small superficial wounds.

2. *The Parts of the Body where they are, and those where they are not.*—They are never found on vital parts, but always where there is little danger of doing much harm.

3. *The Clothes of the Person pretending to have been assaulted.*—The cuts in the clothes do not, as a rule, correspond with those on the body; for instance, a long cut in the coat, and a short one in the body, or *vice versa*.

POINTS OF IMPORTANCE TO BE NOTICED IN EXAMINATION OF A DEAD BODY FOUND WOUNDED.

1. Note situation, extent, depth, breadth, length, and direction of wound. Take careful measurements, in order to determine the character of the weapon, and the organs of the body injured.

2. Is there any appearance of ecchymosis, or is the effused blood liquid or coagulated?

3. Examine wound as to presence of pus, adhesive inflammation, gangrene, or foreign bodies.

Why? Presence of pus, etc., will show that death must have taken place some time after the wound was inflicted.

4. In all examinations of wounds, be careful to disturb as little as possible their outward appearance, in order to compare the wound with the suspected weapon.

5. All notes should be taken during such examination, or *immediately* after.

6. Make a careful examination of all the important organs of the body.

Why? In order to disprove the suggestion that death was due to other causes—poison, disease, etc. This is important, as in the case of a girl who, dreading a whipping, swallowed some arsenic, from which she died, yet her father was tried for causing her death by the severity of his punishment.

7. Only facts should be stated in the Report; *no inferences* should be drawn or suggested.

8. In describing the appearance of wounds use *simple untechnical language*, and avoid superlatives and high-flown words to describe and explain simple facts. Fuller says: "To clothe low grovelling matter in high-flown language is not fine fancy but flat foolery."

9. In gunshot wounds, note position of body, state and contents of the hands, and the direction of the wound in relation to external objects.

Note also in all kinds of wounds the relationship of the wound to cuts or rents in the clothes of the deceased.

THE SEVERAL KINDS OF WOUNDS.

(1) Incised; (2) Punctured; (3) Lacerated and Contused; and (4) Gunshot.

1. Incised Wounds.

Made by sharp instruments.

General Characters.—Incised wounds are somewhat spindle-shaped, their superficial extent being greater than their depth;

the edges are smooth and slightly everted, and always larger than the weapon which inflicted them—due to retraction of the divided tissues. If a wound be in a line with the fibres of a muscle, there will be less "gaping" than when the wound is directly or obliquely across the muscle. Due to muscular contraction, or the elasticity of the skin, an incised wound may assume a crescentic form. The cellular tissue is infiltrated with blood, and coagula are found at the bottom and between the lips of the cut. It must be borne in mind that a wound with smooth edges may be made by a *blunt* weapon over bones near the surface, as on the scalp and over the tibia or shin, but a certain amount of contusion may, in most cases, be detected by careful inspection a short time after the receipt of the injury. Remember the case before mentioned of an incised wound made by a cricket ball.

It is often of importance to distinguish where the weapon entered, and where it was drawn out. The end where the weapon entered is usually more abrupt than the other, which is naturally more drawn out. But in some cases I have seen, where the weapon was simply drawn across the part, both ends of the wound were alike.

Danger to Life from Wounds.—In the case of incised wounds the danger is due to hæmorrhage; to internal hæmorrhage, the result of injury to a large vessel; or to suppuration and formation of an abscess in punctured wounds; to destruction of the parts followed by exhausting suppuration and gangrene in lacerated wounds.

Death from Hæmorrhage.—The surface of the body, lips, and gums are pale and exsanguine. The venous trunks, lungs, and other organs contain but little blood, but the veins of the pia mater are generally not emptied. Hypostasis, both external and internal, occurs on dependent parts of the body. Blood is found round the body, unless the hæmorrhage has been internal. It is often impossible to detect the particular vessels from which the blood has flowed; but this is not of much importance The signs of death from this cause may be rendered obscure by putrefaction; but if nothing be found to account for death but the presence of a wound, we must conclude that death has been caused by it.

2. Punctured Wounds.

The orifice is generally a little smaller than the weapon. A stab may sometimes present the appearance of an incised wound; the depth will, however, help to distinguish the one from the other. The wound may not at all correspond with the shape of the weapon, and the same pointed instrument may produce very different-shaped wounds in different parts of the body. On dissection, two or more punctures may be found in the soft parts, with only one external orifice; these are due to the weapon being only partially withdrawn at each stab. Punctured wounds are always more dangerous than incised. They cause little, if any, haemorrhage externally, unless a large vessel, such as the femoral artery, be injured. These wounds generally heal by suppuration, and not infrequently an abscess is formed in and around the track of the wound. Perforating wounds generally have a large entrance wound with inverted edges, and a small exit with everted edges; if the weapon be rough, the reverse may be the case.

3. Lacerated and Contused Wounds.

The edges of these wounds are never smooth, and generally do not correspond at all with the weapon. A considerable amount of contusion or bruising surrounds the solution of continuity of the part. Hæmorrhage from these wounds is usually slight. A point of considerable interest may arise in connection with this class of wounds; the defence may declare that the injury was the result of a fall, and not due to a blow. The history of the case, and the presence of a bruise where no theory of a fall can explain its existence, will often afford the only solution of the difficulty. Lacerated wounds heal by suppuration, generally with more or less sloughing. Scratches with the finger-nails may be considered as lacerated wounds, but the skin is merely abraded, not divided. They are never important as wounds, but often as a proof of a struggle in cases of rape, etc. Bites are also lacerated wounds. The diagnosis of lacerated and punctured wounds, whether inflicted before or after death, will depend on much the same grounds as those of incised wounds, hæmorrhage, vital reaction, etc.

The following Tables, as aids to diagnosis, are given by Woodman and Tidy:—

Incised Wounds.

IN THE LIVING.	IN THE DEAD.
1. Edges sharply cut and everted, the skin and muscles being retracted.	1. Edges close, and not everted.
2. Bleeding copious, and generally arterial.	2. Bleeding absent or scanty.
3. There are clots.	3. There are no clots in most cases ; sometimes a few strial clots.
4. There is a good deal of staining or diffusion of blood in the muscular and connective tissues.	4. There is little or no staining or diffusion of blood in the tissues of the wound.
5. After some hours or days there will be signs of repair or inflammation.	5. There will be no attempt at repair, and no signs of inflammation. There may be signs of putrefaction.

Lacerated Wounds.

IN THE LIVING.	IN THE DEAD.
1. There will be more hæmorrhage and staining from the blood at first.	1. There is hardly any hæmorrhage or staining unless large veins are torn across.
2. After a few hours, or days, there will be suppuration or other sign of repair ; inflammation or gangrene may also supervene as in incised wounds.	2. No evidence of repair, or inflammation, or gangrene can be detected.

Contused Wounds.

IN THE LIVING.	IN THE DEAD.
1. There is swelling and, after a few hours or a few days, if deep-seated, the skin changes colour, particularly at the edges.	1. There is little swelling or change of colour.
2. There is effusion of liquid blood and lymph in the deeper parts, and coagula form.	2. Very little blood is effused. There are hardly any clots.
3. The swelling subsides and the colours fade after some days, or, in some cases, weeks.	3. There are no rainbow-like or prismatic changes of colour.
4. Abscesses may form, or ulceration, sloughing, or erysipelas set in.	4. No abscesses form, and no erysipelas or dangerous changes are met with.

4. Gunshot Wounds.

The appearance which gunshot wounds present will to a great extent depend upon the form of the projectile, and the distance at which the firearm was discharged. Round balls make a larger opening than conical. Small shot, fired within a short distance of the body, make one large ragged opening. The scattering of the shot depends on the calibre of the gun, on the charge of powder, and essentially on the distance. A charge of ordinary (No. 5) shot, to make a single hole, must have been fired at less than *one foot;* but experiments should always be made with the alleged weapon. A patent cartridge would make a single hole at a considerable distance—five or six yards. Round bullets may split, but the conical ones seldom do. The edges of wounds produced by the discharge of firearms are always more or less ecchymosed; this condition appears in about an hour after the infliction of the injury. If the ball strikes obliquely, the edges of the wound may be much lacerated, or the opening may be valvular and of small size, if the skin over the part be in any way tightened, or if a conical ball has been used. The injury to bones is greater from conical than from round balls. The old round balls were easily deflected; the conical are not so easily turned aside. The track of the ball *widens as it deepens.* This is the reverse of an ordinary punctured wound. The ball may either lodge in a part, or perforate it. Should it have lodged, it must be preserved and compared with the alleged firearm. Bits of clothing or wadding may be carried into the wound. The latter should be carefully kept, as they may prove important as a means of identification. The aperture of entrance and exit must, if possible, be determined. On this point there is much difference of opinion. The wound of *exit* is always *smaller* than the wound of *entrance* (Casper). In this opinion Casper agrees with M. Malle, Olliver d'Angers, and M. Huguier, but is opposed by Taylor, M. Matthysens, and others. "The characters of a gunshot wound," says Assistant-Surgeon Neill, "are those of a contusion and laceration of all the tissues. Sometimes they are so simple as to bear resemblance to a punctured wound, particularly if a rifle-ball (conoidal), revolving on its long axis, has passed through the soft parts at a great speed, but within a few hours it resembles a contusion. The wound of entrance, as it has been termed, bears no com-

parison in size or shape to that of the exit when a rifle-ball has caused the injury. In the former you see the edges of the wound curving inwards, and the circumference small, with little or no hæmorrhage. In the latter, the wound is large, with torn and irregular edges projecting outwards, and perhaps only slight oozing of blood. In a short time, averaging an hour, round the entrance wound slight redness begins, gradually extending to about two inches round its orifice. Again, this colour changes to a blue or greenish black, and you see all the appearances of a severe bruise, with a small wound of the skin, its edges still curved inwards. In the exit wound the discoloration of the skin is not apparent." The probable reason for the discrepancies in the statements of observers, as to the characters of entrance and exit wounds, may be found in the fact that experiments have been conducted with different-sized balls, different kinds of weapons, with varying quantities and qualities of the powder used, the character of the wads, and with varying velocities and distances. As pointed out by M. Roux, the two openings may be equal if the ball preserves the same velocity through the tissues as it possessed before entrance; the *entrance* hole is smaller than the *exit*, when the ball has lost much of its trajectile force, and enters the softer parts of the body first; the *entrance* is larger than the *exit*, when the ball first enters through the denser tissues of the body, and leaves through the softer.

Husband gives the following account of a case:—"A farmer, whilst sitting in a boat, was in the act of moving a muzzle-loading rifle to make room for his dog, when the weapon was accidentally discharged. The bullet, a round one, half an inch in diameter, entered the left axilla and passed out midway between the spinal column and the right border of the left scapula. On moving the arm from the body, a round hole the size of a shilling, opening into a dark cavity, was found at the top of the axilla, and on turning the body over, a small triangular slit was found, with no eversion of the edges. In fact, I had to search for the exit wound. The muzzle of the rifle must have been somewhat less than the length of the arm from the point the bullet entered. The relative size of the holes in the clothes corresponded with those in the body. The brother of the deceased, who drove me home, and who was present when I examined the body, voluntarily remarked that had he not

known how the accident occurred, he would have sworn that his brother had been shot from the back; for in shooting animals, pigs, etc., he had noticed that the wound of exit was always larger than the wound of entrance." This case goes to prove the statement of Casper, whose experience was obtained from the results of point-blank firing on barricades at probably similar distances to that in the case of the farmer just mentioned. The opening of entrance made by the ball has generally, but by no means always, inverted edges. The edges of the exit opening are everted, bloody, and raw; but both the entrance and exit wounds may be everted in fat persons, due to the protrusion of the fat; and this eversion may also result from the expansive power of the gases generated during putrefaction, should this condition be present. Wounds made by *double shots*, as from double-barrelled guns, or pistols, or from slugs fired from one barrel, diverge after their entrance into the body.

Observations during the recent war in South Africa throw fresh light upon the results of gunshot wounds produced by modern projectiles. Of wounds produced by the Mauser bullet, one correspondent (*The Physician and Surgeon*, 1900, p. 49) states that "the aperture of entrance seldom shows any bruising of surrounding tissue; frequently it has been difficult to locate it, for where the skin is dense and elastic, there is seldom any bleeding. There is never any inversion of the edges, which are sometimes circular in form, and sometimes triangular like a leech-bite. The aperture of exit, where the bullet has not been distorted, is seldom any larger than that of entrance; there is no bruising of surrounding tissue, and no eversion of the edges; bleeding varies, of course, in accordance with the proximity of large, medium, or small blood-vessels in the track, but in the vast majority of cases it is slight."

The late Sir William MacCormac, quoted by Sir William Stokes (*B. M. J.* vol. i. 1900, p. 1453), says, "I saw a large number of injuries inflicted by the Mauser bullet, which is remarkable for the small wound it produces. In three-fourths, if not a larger proportion, it was impossible to tell the exit from the entrance wound, they were so similar in appearance."

In the examination of gunshot wounds we have to consider—

1. *Direction in which the Gun was fired.*—The track and

position of the ball in the body, coupled with the relative position of the body to a window or door through which the gun may have been discharged, and the place where the ball is found, should it have passed through the body, may assist us in forming an opinion. It is often impossible to trace the course of the ball through the cavities of the body, but through the muscles and denser structures this is more easily accomplished. The effects of the ball on surrounding objects may assist very much in finding the direction of its course. Sir Astley Cooper, by a careful consideration of the above suggestions, once correctly determined that a left-handed man had fired the fatal shot.

2. *Distance at which the Charge was fired.*—In the case of wounds inflicted by small shot, the scattering of the shot must be our guide. Dupuytren has related a case in which a fowling-piece charged with powder alone and fired at a distance of two or three feet from the abdomen made a round hole in the belly and killed the man. The absence of scorching, or marks made round the wound by the half-burnt powder, allows of the assumption that the shot must have come from some distance —rather more than four feet. The absence of any of the above, however, is not an absolute proof that the shot has come from a distance.

There is no means of deciding, from an examination of a pistol or gun, when the weapon was last used. In all cases medical men, unless sportsmen and familiar with firearms, should hand over the weapon to a gamekeeper or gunsmith, and not attempt to give an opinion on matters about which they know nothing. The following may be of use to students for examination purposes, but for nothing else:—Among the products formed when gunpowder is exploded is the sulphide of potassium, but if exposed to the air some portion of this substance is converted into the sulphate of potash. If, then, the gun-barrel be washed out with distilled water, and the washings filtered, and, on the addition of a solution of acetate of lead, a black precipitate of sulphide of lead be formed, this is supposed to point to recent use; if, on the other hand, a white precipitate of sulphate of lead forms, to the use of the weapon at some more distant date than the period alleged.

CHAPTER VI.

BLOOD-STAINS.

It is important in medico-legal investigations to determine the nature of stains found on clothes, weapons, articles of furniture, etc. In the case of blood-stains note should be made of their incidence upon the body or in its vicinity. Blood-stains may vary in their character, incidence, and magnitude, as sprays, spirts, or jets; smears of various forms, or pools of blood.

Notes should be made of the relation of the direction of a spray of blood to the position of a wounded body when found. A plan with the position of the stains should be sketched upon the spot, and measurements taken carefully.

In the examination of blood-stains the purpose of the medico-jurist is not to demonstrate all the properties of blood, but to identify it. There is not much difficulty in ascertaining whether stains are due to blood or not; but when the question arises as to whether the blood be human or that of some other animal, the identification is in most cases impossible.

Blood-stains vary in colour, according to the age of the stain, the quantity of blood in it—the thicker the stain the darker—and the nature and colour of the material upon which it is. Recent stains are reddish in colour, old stains brownish. This change of colour depends upon the free access of air and the presence or absence of chemical substances in the air, so that it is almost impossible to infer the age of a blood-stain by its colour. On dark-coloured materials the stains are rendered more visible by the aid of artificial light, such as candle-light; on light-coloured materials, on leather, wood, iron, and stone, they are more visible in good daylight. By reason of the coagulation and the albuminous composition of blood, dry

stains stiffen the fabric when thin, and on thicker woollen materials the fine fibres become matted. On metals, such as iron or steel, they appear as dark shiny spots or smears, and when dried are often fissured or cracked. Rust may so alter blood as to produce a difference between the stains on the blade and handle of a knife. In quite recent blood-stains the general appearances are sufficient to give rise to a conclusion as to their nature, especially if the stains are large. The general features as seen by the naked eye are such that one may often recognise blood-stains as arterial by the *comet shape* they retain, when falling slantwise on an object. Venous blood is not spurted in small jets like arterial, but blood from veins may become splashed upon objects and assume shapes similar to those produced from an arterial jet.

EXAMINATION OF BLOOD-STAINS.

The examination of blood-stains should be carried out in the following way :—

Physical Examinations.

1. Examine the stains carefully with a good pocket lens or a low-power microscope lens. A fabric will show matting of its fibres, red filaments, and minute coagula in its meshes. In old blood-stains coagula may be absent and the fabric appear as if dyed. The characters of any fibres or hairs adhering to the stain and the nature of the substance upon which the stain is should be noted.

2. Make accurate notes of the position and shape of the stains on the material examined.

3. Take one stain, if there are several, or part if single, and note the solubility of it in water, or in a mixture of water and some other substance. The solubility of the colouring matter is greater if the stain be recent than if it be old. The older the stain the less soluble it becomes, as the hæmoglobin is gradually changed in course of time to insoluble hæmatin.

An endeavour should be made to obtain a solution for microscopical, chemical, and spectroscopical examination. The solvent, in order to obtain the blood corpuscles in as natural a form as possible, should approach in its specific gravity the *liquor sanguinis*.

The following solvents fulfil this purpose :—

(*a*) Glycerine and water, 1 to 7 (sp. gr. 1030).
(*b*) Pacini's solution of chloral hydrate in water (1 in 10).
(*c*) Normal saline solution.
(*d*) Roussin's solution of glycerine 3 parts, sulphuric acid 1 part (by weight), and water so that the mixture shall have a sp. gr. of 1028.
(*e*) Saturated solution of borax in distilled water. If distilled water alone be used, the red corpuscles lose their hæmo-

FIG. 2.—Photo-micrograph of wool fibres, ×250. (R. J. M. Buchanan.)

globin and become "laked" or "phantom" corpuscles; if the solution be of higher sp. gr. than *liquor sanguinis*, then the corpuscles become crenated and irregular in shape.

The technique of examination has to be varied in certain details, according to the material upon which the stain is. Stains may have to be examined upon cloth-fabrics, wood, plaster, metal, or leather. These will be taken separately, and the methods of examination described which will prove most reliable in each case.

1. *Cloth-fabrics.*—Cut out a stain, or part of one, and macerate it in a quantity of one of the solvents mentioned above, sufficient for the purpose. If the stain be very small, squeeze with fine forceps one or more drops upon microscope slides for microscopic, and keep the remainder of the solution for spectroscopic, examination. In dyed fabrics, which have been mordanted, the mordant may fix the blood-stain so

FIG. 3.—Photo-micrograph of flax fibres, ×250. (R. J. M. Buchanan.)

as to prevent solution, and especially so when attempts have been made to wash out the stain with soap and water.

To make a solution of the stain in such cases it is best to use distilled water to which a small quantity of ammonia or citric acid has been added ; in one or other of these the colouring matter will dissolve.

2. *Wood.*—Note the kind of wood, cut off a thin shaving and treat with one of the solvents mentioned above. If on wood containing tannic acid, such as oak or elm, the best solvent is a two per cent solution of hydrochloric acid.

3. *Plaster.*—Scrape off some of the stained plaster, and treat as for cloth or wood.

4. *Metal.*—If the stain be upon a clean and unrusted metal, *e.g.* the clean blade of a knife, then gently heat the metal on the side opposite to the stain, when the latter, if recent, will peel off or can be easily detached. This requires some care and dexterity. It is easy, however, to scrape the stain off into a watch-glass, and this procedure is necessary when the metal

Fig. 4.—Photo-micrograph of silk fibres, ×250. (R. J. M. Buchanan.)

is rusted and the stain mixed with the rust, or when the stain is thin.

If on iron and mixed with rust the borax solution may be used, with a drop or two of solution of ammonia; use a fine camel-hair pencil dipped in the solution, and brush the stain off into a watch-glass. Becker advises that stains mixed with rust should be digested with a weak solution of ammonia and common salt for a few hours; decant the solution and evaporate it upon a microscope slide to dryness, then test the residue by the "hæmin test."

Ganttner's test should be used to a portion of a stain upon metal when thin or mixed with rust. It may be carried out upon the metal itself or upon a scraping of the stain in a watch-glass, resting upon a black surface. Moisten the scraping in a watch-glass with a drop or two of distilled water rendered feebly alkaline, then add a minute drop of hydrogen peroxide. Wherever blood is present bubbles of gas develop, which give the material a white beaded appearance. The froth develops

FIG. 5.—Photo-micrograph of cotton fibres, ×250. (R. J. M. Buchanan.)

from the outside of the drop towards the centre when the stain is mainly composed of blood. In a scraping consisting of mixed particles of rust and blood, the reaction only appears upon the particles of blood, and rust to which blood adheres ; it does not take place on those particles of rust free from blood. Before adding the peroxide of hydrogen it may be necessary to dissipate any air-bubbles which may cling to the scraping in the alkaline water by gentle agitation with the point of a fine glass rod. Should the above reaction with peroxide of hydrogen

not take place, then one can rest assured that no blood is present. The test, however, is a negative one: it is not a positive test for blood only; other fluids and exudations from the body, such as saliva and pus, give the reaction. The reaction will take place with blood-stains of any age.

In examining a clasp-knife or any hinged weapon for blood-stains, the instrument should be taken to pieces and all the hinges and recesses carefully examined, for in these places blood may be found, although the weapon had previously been wiped clean, and appear free from stains.

5. *On Leather.*—The tannic acid in leather forms a compound with blood which is insoluble in the solvents generally used. A thin shaving of the stained portion should be taken and folded, with the stained surface outwards, in the form of a loop. If the outer surface of the loop with the stain be made to touch the surface of the glycerine and water solution, at the same time taking care that the leather itself be not moistened, a recent stain may yield a sufficient quantity of colouring matter for the purposes of examination. Failing this, the shaving should be digested in a small quantity of a two per cent solution of hydrochloric acid in distilled water (SORBY).

Microscopical Examination.

The microscopical examination of blood-stains, for the purpose of identifying the presence of the red blood corpuscles, is especially applicable to recent stains. In these the corpuscles may retain, to a great extent, their normal characters; but their condition varies with the age of the stain; they become altered in appearance and irregular in shape with increasing age, until a stage is reached when they become completely disintegrated and unrecognisable. Having obtained a solution of a stain by one of the methods recommended, a few drops should be placed upon a clean microscope slide and covered with a No. 1 cover-glass. In a recent stain, where minute coagula are present, one may be placed on a microscope slide and moistened by breathing upon it several times, and then covering it with a No. 1 slip, or a drop of the glycerine solution may be allowed to act upon it on the slide until it be sufficiently moistened, when it should be covered in the same way. The preparation should be examined through the

microscope with a good lens (preferably a $\frac{1}{12}''$ oil immersion), magnifying 300 to 400 diameters, and if any corpuscles be found, their characters should be carefully observed and noted.

All such specimens should be carefully preserved and labelled with a description of the method of preparation, the case to which they belong, the date of preparation, and the signature of the individual who has made and examined them. It is essential that the preparation and examination of the specimen should be made by the same individual. In certain cases the conditions may be sufficiently favourable to allow of the production of stained specimens, which can be mounted so as to retain their original characters permanently. In every case it is advisable to pursue the investigation with this object in view.

This process is especially applicable to recent blood-stains, in which, from preliminary examination, the presence of blood corpuscles has been determined; where complete disintegration of the blood corpuscles has taken place it would not be of any value.

It may so happen that by means of stained specimens the identity of blood corpuscles may be more easily established, when the result of examination is uncertain in a specimen not so prepared.

By the action of certain dyes upon the corpuscles their special features are rendered easier of recognition. Any of the approved methods of preparing blood films for general clinical purposes, which will suit the circumstances, may be employed. An easy and reliable method is as follows. A drop of the solution of the blood-stain properly prepared as previously recommended, or if obtainable a small coagulum moistened with normal saline solution, is placed on a clean coverslip and spread evenly over its surface with the aid of a fine glass rod. The film is allowed to dry in the air, covered with a watch-glass for protection against dust. When dry it is passed three times through the flame of a Bunsen burner, or placed in a mixture of equal parts of absolute alcohol and ether, to fix it. After fixation it should be placed for a minute or more in an aqueous solution of eosin.

Any excess of stain should be removed by washing in distilled water, and the specimen allowed to drain by standing it on edge upon a piece of filter-paper; it should then be

allowed to dry, and then counterstained with a freshly prepared aqueous solution of methylene blue, haematoxylin solution, or other nuclear dye. Wash again in distilled water, allow to dry, and mount in Canada balsam. By this method the corpuscle will be stained pink, and if nucleated, the nucleus will be stained by the methylene blue, haematoxylin, or other nuclear stain which may have been used.

When examining specimens prepared from blood-stains, it is necessary to search carefully for other cellular structures such as epithelial cells, spermatozoa, or fragments of hair.

It may be advisable, in certain cases where the amount of material submitted for examination is small, to centrifugalise some of the solution in a fine glass tube, in order to determine any cellular elements present to one spot. By making use of this concentrated portion containing the cellular elements for the preparation of a microscopic specimen, one not only facilitates the microscopical examination, but is able to place more reliance upon the results obtained.

The Results of Microscopical Examination of Blood-Stains in their Medico-Legal Relations.

As previously stated, the examination of alleged blood-stains from a medico-legal standpoint is pursued essentially for the purpose of testifying as to whether they have been produced by blood or not. Where the examination yields a negative result, further procedure is necessary with a view of identifying the true nature of the stain. Should, however, the result be positive, the question arises as to the possibility of distinguishing between human blood and the blood of other animals, and determining the exact animal from which the blood has been derived. Such an examination should be pursued in full recognition of its importance as a factor towards the establishment of truth essential to the administration of justice.

To fulfil this obligation the methods employed should be so selected as to produce results bearing testimony free from any possibility of doubt.

Certain differences exist, and may be detected by microscopical examination, between the red corpuscles of human blood and those of some other animals sufficiently well marked

to render differentiation possible. The differences are those of form and structure.

(1) In *man* the red corpuscles appear as *circular* biconcave discs, averaging $\frac{1}{3500}$ of an inch in diameter, and are non-nucleated.

The red corpuscles of mammals present the same features, with the exception of the

(2) *Camel* tribe, in which the corpuscles are *oval* in form, but non-nucleated.

(3) In *birds*, *fishes*, *reptiles*, and *amphibians* the red corpuscles are *oval* in shape, and possess a nucleus.

Guided by the above facts, one is able to testify whether or not the corpuscles conform to the characters of mammalian blood.

Many attempts have been made with a view to establishing a reliable means of differentiation between the red blood corpuscles of man and other mammals (the camel excepted), and with a certain degree of success, such as might be expected, under select conditions favourable to histological research, but which do not obtain in medico-legal practice. Differences in size of the red corpuscles, as revealed by micrometric measurement, have been suggested as a possible means of distinguishing between the blood of different mammals. Of the common animals, the red blood corpuscles of the sheep present the most marked difference in size compared with those of man. The following table of the dimensions of red blood corpuscles is derived from measurements made by Treadwell, and quoted by White (*The Medico-Legal Journal*, New York, 1895):—

	μ.		μ.
Human . .	7·940	Horse . . .	5·503
Dog . . .	6·918	Cat . . .	5·463
Rabbit . .	6·365	Ox . . .	5·436
Ass . . .	6·293	Sheep . .	4·745
Pig . . .	6·101		

Menstrual blood contains no fibrin, has an acid reaction due to the vaginal mucus which keeps it fluid, and contains squamous epithelial cells. None of these characters can be differentiated on fabrics, especially when contaminated with urinary stains in addition. Hence, in cases of alleged rape, no distinction can be drawn between blood-stains on the under-clothing of the female, which may have arisen from hæmorrhage

the result of violence to the sexual parts, and those which might have arisen from the ordinary menstrual flow or menorrhagia. The detection of spermatozoa, however, would add considerable value to the observation.

Blood Crystals.—Professor Preyer of Jena pointed out many years ago that the hæmoglobin crystals from the blood of some animals differed in shape from those of man, and this fact has given rise to many attempts to trace the identity of the blood to the animal from which it has been derived. The results have not been of sufficient value to establish it as trustworthy for medico-legal purposes. Dr. Monckton Copeman (*B. M. J.* vol. ii. p. 190, 1889) has carefully investigated the subject, and his researches, partly confirmed by Professor Glaister of Glasgow, show that from the guinea-pig, rat, and squirrel, crystals of hæmoglobin may be easily obtained, but the solubility of human hæmoglobin renders it much more difficult to crystallise. Crystals may, however, be obtained in the following ways :—

(*a*) By feeding leeches on human blood, crystals may be found, after some weeks, in the gastric dilatation of the alimentary canal.

(*b*) By diluting human blood with the fluid from hydrocele, ascites, or pleurisy when they have undergone decomposition.

(*c*) By adding crystals of glycocholate or taurocholate of soda to human blood.

(*d*) By adding a drop of cat's bile to human blood on a microscope slide, but the crystals are those of reduced hæmoglobin.

Crystals of human hæmoglobin appear in the form of rectangular plates, with a greenish or pale claret colour. On spectroscopic examination they exhibit the characters of reduced hæmoglobin, in contradistinction to the crystals derived from the lower animals, which produce the spectrum of oxyhæmoglobin.

The blood of the bullock, sheep, and pig is very difficult to crystallise. By the method adopted by Gamgee of adding to defibrinated blood one-sixteenth its volume of ether, shaking until the mixture becomes transparent, and allowing to stand

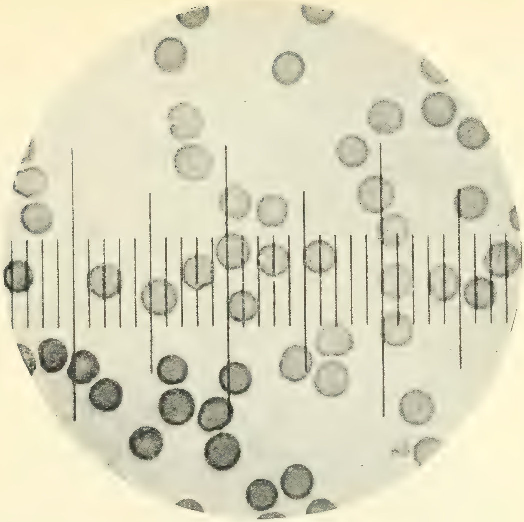

FIG. 6.—MEASUREMENT OF BLOOD CORPUSCLES.
Photo-micrograph of human red blood corpuscles, ×800. Each corpuscle in diameter covers two divisions of the scale. Compare with sheep's blood, Fig. 7. (R. J. M. Buchanan.)

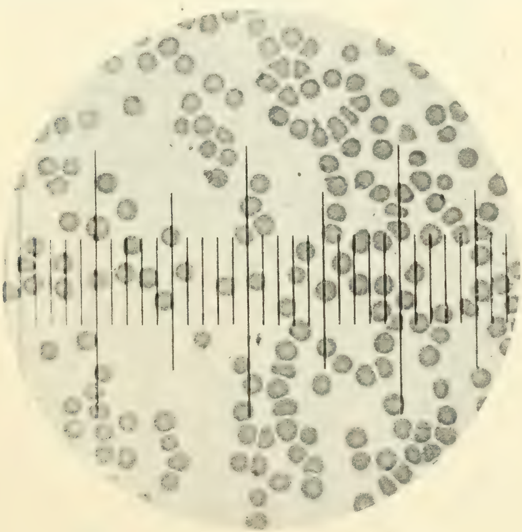

FIG. 7.—MEASUREMENT OF BLOOD CORPUSCLES.
Photo-micrograph of red blood corpuscles from the sheep, ×800. The diameter of the corpuscle covers one division of the scale. Compare with human blood, Fig. 6. (R. J. M. Buchanan.)

in an ordinary temperature for 48 hours, crystals may be obtained from the blood of the following animals:—

1. Horse.	5. Dog.	8. Squirrel.	11. Mouse.
2. Bullock.	6. Cat.	9. Guinea-pig.	12. Chicken.
3. Sheep.	7. Rabbit.	10. Rat.	13. Pigeon.
4. Pig.			

Crystals from human blood are not easily obtainable by this process, but when they are, they always give the spectrum

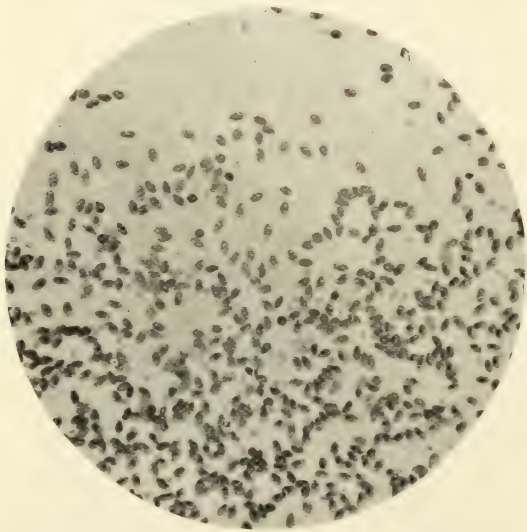

FIG. 8.—Photo-micrograph of red blood corpuscles from domestic fowl, ×250. (R. J. M. Buchanan.)

of reduced hæmoglobin, whereas those from the animals mentioned above give the spectrum of oxyhæmoglobin.

Chemical Examination.

Having obtained a coloured solution from a supposed blood-stain, if sufficient in quantity, to separate portions apply the following chemical tests:—

1. Add a few drops of a weak solution of ammonia in distilled water. The colour may remain unchanged, or, at the

most, a *slight* heightening may take place, if it be due to blood. If the solution of ammonia be too strong, a brown colour may be produced if blood be present.

2. Heat to boiling, when the following changes take place if blood be present :—

(*a*) The colour may disappear.
(*b*) Coagulation follows.
(*c*) A precipitate falls, dirty grey or brown in colour, depending upon the amount of colouring matter present.

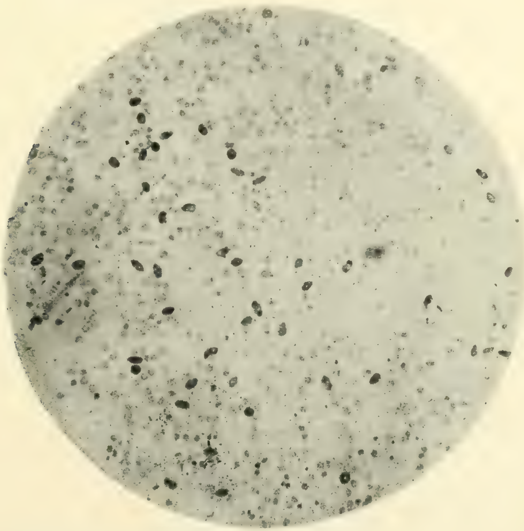

Fig. 9.—Photo-micrograph of blood corpuscles of fish, ×250. (R. J. M. Buchanan.)

On adding caustic potash to the precipitate it will dissolve, and the solution formed will appear greenish by transmitted and red by reflected light. This phenomenon is called the *dichroism* of blood. Authorities differ in opinion as to whether the colour is green by transmitted and red by reflected light, or *vice versa.* "As a matter of fact, the phenomenon is chameleon-like as regards colour, so that both sets of observers may be considered right or wrong" (Glaister).

3. Add tincture of guaiacum, freshly prepared: an opaque, cream-coloured precipitate will form of the guaiac resin in the aqueous solution. On the addition of ozonic ether, turpentine, or peroxide of hydrogen, a blue colour will be produced at the junction of the fluids: proportionate to the amount of blood-colouring matter present, the blue colour will vary in intensity.

This test, known as Day's or Schönlein's, is extremely delicate, and *reacts to no coloured substance except blood.*

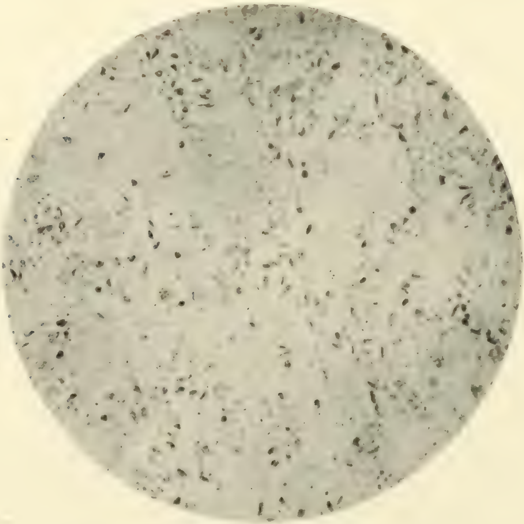

FIG. 10.—Photo-micrograph of blood corpuscles from a dried stain of the blood of a codfish, ×250. (R. J. M. Buchanan.)

In cases where the blood-stain is small, the test may be applied as follows. Moisten a pure white filter-paper with a drop of distilled water, or one of the solutions recommended in the section on physical examination, and touch the stain with the moistened portion. On adding a drop of tincture of guaiacum followed by a drop of ozonic ether to the wet filter-paper the blue colour will be produced and easily recognised on the white surface.

The guaiacum test, although extremely delicate, can only be accepted as providing negative evidence. The absence of reaction proves the absence of blood, except in *very old* blood-stains, which may not respond to the test. The blue colour produced indicates that the substance *may* be blood, but it cannot be accepted without corroboration. Gluten, raw potato, milk, bile, sweat (Ogston), and other oxidising substances give a blue colour with guaiacum and ozonic ether; some substances give the blue colour with guaiacum alone.

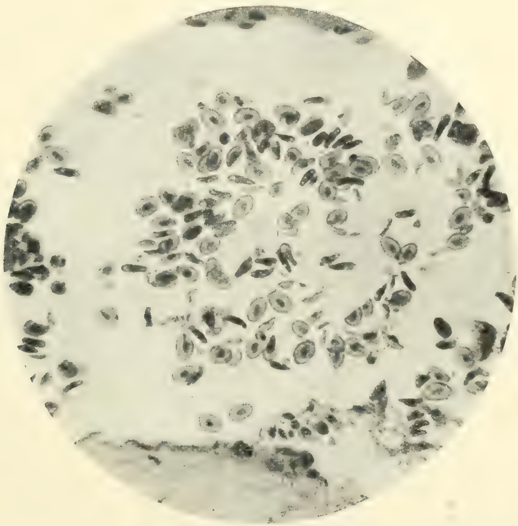

FIG. 11.—Photo-micrograph of frog's blood showing oval nucleated red corpuscles, ×250. (R. J. M. Buchanan.)

With blood, however, the test is sufficiently delicate to detect one drop in six ounces of water.

4. *Nitric acid* added to a portion of the solution of blood in distilled water produces a whitish-grey precipitate.

5. *Hæmin Crystals.*—Concentrate a portion of the solution upon a microscope slide, add to it a minute crystal of chloride of sodium and a few drops of glacial acetic acid. Heat gently to dryness or to a lesser degree under a coverslip; examine

with the microscope; if blood be present, crystals of hæmin, or the hydrochloride of hæmatin, will be found. They are of a yellowish-red or brownish-black colour with a metallic lustre. They occur in rhomboidal prisms, or six-sided in shape, or in the form of "whetstones," often in clusters; many of the crystals exhibit a lipped projection on one side. They are known as Leichmann's crystals. It is well to verify their

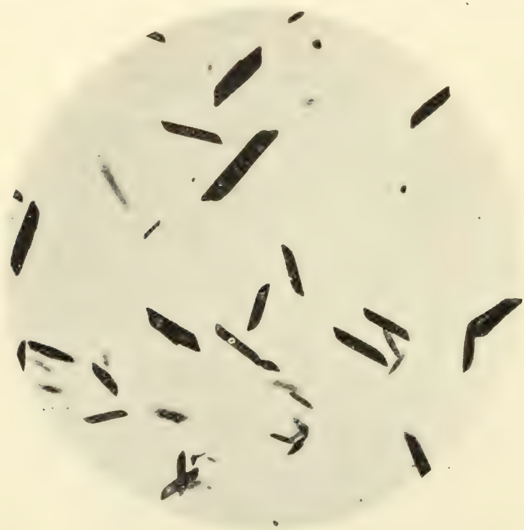

FIG. 12.—Photo-micrograph of crystals of hæmin, ×250. (R. J. M. Buchanan.)

origin from blood by placing upon them a drop of hydrogen peroxide, when they will give off bubbles of oxygen gas.

They are insoluble in water, alcohol, and dilute acetic and hydrochloric acids. They dissolve in boiling acetic or hydrochloric acids, and the caustic alkalies. They respond to the guaiacum test, and the ash produced by incineration shows the presence of iron by the red colour produced on the addition of a drop of hydrochloric acid and a solution of potassium sulphocyanide.

The production, by the methods described, of such crystals affords conclusive proof of the presence of blood.

Spectroscopic Examination.

To a portion of the coloured solution, filtered if necessary, the spectroscopic tests should be applied. The following points must be remembered in carrying out a spectroscopic examination:—

(*a*) The colouring matter of fresh blood is hæmoglobin, and it may exist in two states, according to the degree of its combination with oxygen.

In arterial blood it is present as oxidised hæmoglobin, and the same obtains in blood which has been exposed to the air under certain conditions and for a varying period of time.

In venous blood, especially when obtained under conditions preventing oxidation, as from the heart cavity of an animal newly asphyxiated, it is present as deoxidised hæmoglobin.

(*b*) In dry stains, especially if they have been subjected to the action of impure air containing the products of coal-combustion, the colouring matter becomes changed into *met-hæmoglobin*, or hæmoglobin in which its combination with oxygen has been altered in such a way that a current of a neutral gas, such as hydrogen or nitrogen, will not disassociate it, as it does with oxyhæmoglobin. Such stains have a brownish colour, and may give an acid reaction.

(*c*) In stains which have retained moisture, from having lain in damp places, the hæmoglobin becomes converted into *hæmatin*. The same change takes place in dry stains after a longer period of time.

On examining the solution of the colouring matter from a blood-stain with the spectroscope, the spectrum will vary according to its condition and the nature of the solvent used.

The spectra of hæmoglobin and its derivatives are characteristic, and afford conclusive evidence of the presence of blood. The spectra must be recognised, however, in more than one condition. Other substances may yield spectra very similar to that of oxyhæmoglobin, but when subjected to certain tests they do not alter in the same way. They cannot be made to give the spectra of reduced hæmoglobin and reduced hæmatin, and any colouring matter which may be made to yield the spectra of reduced hæmoglobin and reduced hæmatin is derived from blood.

Blood Spectra.

1. *Oxidised hæmoglobin* (O_2Hb) is characterised by the presence in its solar spectrum of two absorption bands between the D and E lines. The first band commences at the D line and extends a short distance towards the E. The second commences at a little distance from it, and terminates at the E

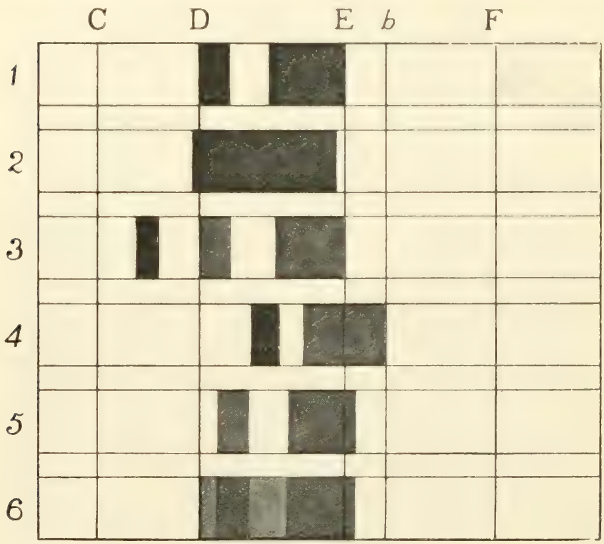

FIG. 13.—BLOOD SPECTRA.

1. Oxyhæmoglobin.
2. Reduced hæmoglobin.
3. Methæmoglobin.
4. Reduced hæmatin.
5. CO hæmoglobin.
6. CO hæmoglobin and reduced hæmoglobin.

line; it is about twice the breadth of the first. The band at D is more defined than the other (Fig. 13, 1).

2. *Deoxidised* or *reduced hæmoglobin* presents one broad band occupying almost the whole of the space between D and E slightly to the left of these lines (Fig. 13, 2).

3. *Methæmoglobin* presents two bands between D and E, in the same position as those of O_2Hb, but in addition a third band between C and D and near to the former (Fig. 13, 3).

A solution of oxyhæmoglobin or methæmoglobin may be

reduced by the addition of a reducing agent, such as Stoke's reagent, consisting of ferrous sulphate with a small quantity of tartaric acid dissolved in water and rendered alkaline with ammonia, or, better still, by the addition of ammonium sulphide. The spectrum will change to that of reduced hæmoglobin.

4. *Acid hæmatin* presents a spectrum with a band between D and E, commencing at a little distance from D and ending at E, also a narrower band between C and D and commencing at C. It is a difficult spectrum to obtain.

5. *Alkaline hæmatin* presents a spectrum with a single band between C and D near to the D line. It is more difficult to obtain than the spectrum of acid hæmatin.

It is not necessary, however, to obtain these spectra, viz. 5 and 6, but it is necessary to reduce solutions of either acid or alkaline hæmatin in order to obtain the spectrum of *reduced hæmatin.* To do so proceed as follows. To some of the solution of colouring matter obtained from the stain add a small quantity of a 20 per cent solution of sodium hydrate; the solution will alter in colour, and the spectrum of O_2Hb or MetHb. will disappear. On adding to this solution of alkaline hæmatin a few drops of ammonium sulphide, or Stoke's fluid, it becomes claret-coloured, and on examination with the spectroscope the spectrum of *reduced hæmatin* will be seen. This is the most pronounced of all blood spectra. Its production can be hastened by gently warming the solution.

If the stain be old and already changed into hæmatin, its solution will yield the spectrum of acid hæmatin, and will give the spectrum of *reduced hæmatin* on the addition of ammonium sulphide or Stoke's fluid without previous alkalisation.

6. *Reduced hæmatin* presents a spectrum with a dark band about midway between D and E, and a broad but paler band commences near the E line and extends to the *b* line (Fig. 13, 4).

In cases of death by asphyxia, in which the hæmoglobin is in combination with CO_2, the blood, if removed and examined immediately after death, gives a spectrum of reduced hæmoglobin, but on exposure to the air it rapidly changes to oxyhæmoglobin. The period after death at which blood is usually submitted for medico-legal examination is sufficiently late to allow of this change, and so prevents the possibility of determining death by asphyxia by spectroscopic examination of the blood. Where death has been caused by the action of *carbon*

monoxide, the blood is of a *cherry-red colour*, and it will retain this colour unchanged for a long time, in fact, for years, due to a stable combination of the CO and hæmoglobin, called carboxyhæmoglobin. Such blood yields a very characteristic spectrum, with two bands similar to those of O_2Hb, but nearer to the violet end (Fig. 13, 6). Their position should be assured by accurate measurement and comparison with a spectrum of O_2Hb. The CO hæmoglobin, however, cannot be reduced; on the addition of ammonium sulphide or Stoke's fluid the bands remain unaltered.

In cases where the amount of fluid obtainable for examination is very small, recourse must be had to the micro-spectroscope, using a Sorby's cell to hold the fluid, and substituting for the eye-piece of the microscope a specially constructed spectroscope arranged so as to throw the spectrum of a known solution of blood-colouring matter alongside of that yielded by the solution under examination. Artificial light should be used, and the D line located by placing in the flame a platinum wire carrying a salt of sodium.

Biological Tests for Blood.

The results of the experimental investigations of Friedenthal,[1] Deutsch,[2] Uhlenhuth,[3] Wasserman and Schutze,[4] Nuttall,[5] Tarchetti,[6] Grünbaum,[7] Metalnikoff,[8] and M'Weeney[9] into "blood relationships" have led to the suggestion of a new method—the "biological test," by which different kinds of mammalian blood may be distinguished one from the other. Their experiments show in a general way that the "serum from an animal which has been injected intraperitoneally with any given organic fluid, will, if mixed in small quantity with a dilute solution of the fluid used for the injection, produce a

[1] Friedenthal, *Archiv für Anatomie und Physiologie*, 1900, p. 494.

[2] Deutsch, *Bulletin Medical*, Sept. 8, 1900; and *Centralblatt für Bakteriologie*, Band xxix. p. 661.

[3] Uhlenhuth, *Deutsch Medicinische Wochenschrift*, 1901, Nos. 6, 17, 45.

[4] Wasserman and Schutze, *Berlin Klin. Wochenschr.*, Feb. 21, 1901.

[5] Nuttall, *Jour. Hygiene*, vol. i. 1901, p. 367; *B.M.J.* vol. i. 1901, p. 669.

[6] Tarchetti, *Gazz. degli Osped.*, May 19, 1901; *B.M.J.* vol. i. 1901.

[7] Grünbaum, *Lancet*, Jan. 18, 1902.

[8] Metalnikoff, *Centralblatt für Bakteriologie*, Apr. 18, 1901.

[9] M'Weeney, *Jour. State Med.* vol. ix. No. 7, p. 378.

more or less definite precipitate." If human defibrinated blood be injected into the peritoneal cavity of a rabbit, the serum obtained from the rabbit's blood, when mixed with a clear solution of the blood of man or ape, will produce a precipitate, and agglutinate the red blood corpuscles if present: the same reaction will not follow if such serum be added to a solution of the blood of any other animal.

Tarchetti advises the following procedure in the examination of blood-stains:—Dissolve the stain in a few drops of a 9 per cent aqueous solution of sodium chloride, filter, and divide the filtrate into two portions; to one (*a*) add 0·5 c.c. of the prepared rabbit serum (the so-called anti-serum); to the other (*b*), serum from a rabbit which has not been injected with human blood. Both are to be placed in an incubator at 37° C. for an hour. By this time, if the solution of the stain be of human or anthropoid origin, the contents of the tube (*a*) will have become turbid, the contents of tube (*b*) will remain clear. From a series of experiments with blood-stains of man and other animals on a variety of materials, Tarchetti states that this method is reliable. Prepared rabbit "human anti-serum" has been shown to have no such reaction with the blood of the pig, ox, calf, mouse, or rat.

Metalnikoff has shown that intraperitoneal injection is not necessary in order to produce an "anti-serum"; feeding a rabbit on the blood will act in the same way.

From the result of his investigations Grünbaum points out that these reactions must be looked upon rather as "special" than "specific," in view of the fact that his "chimpanzee anti-serum" gave a *slight* but distinct turbidity after a few hours with horse blood. He also suggests a method for the microscopical application of the "biological test," by using a 1 per cent blood solution with a drop of "anti-serum." This method has enabled him to distinguish between human and anthropoid blood, the reaction occurring earlier and being more complete when the "anti-serum" is used on its own blood. The "biological test" is of great interest, and, although in the experimental stage as yet, gives promise of utility in medico-legal inquiries. Whether it will ever become a test sufficiently reliable for medico-legal purposes remains to be proved.

Vegetable and other Stains which resemble Blood.

Certain vegetable colouring matters give spectra which may be mistaken for blood, from their close similarity. Of these cochineal dissolved in a solution of alum gives two bands similar to O_2Hb. On the addition of boric acid the bands move to the violet end of the spectrum, but they are unaffected if the colouring matter be blood. Lac-dye, alkanet root, madder, and others also give spectra resembling O_2Hb, but they are changed or disappear on adding ammonia or sulphite of potassium, while the spectrum of blood remains unaltered.

As stated previously, spectra of colouring matters other than blood are not capable of being altered by reducing agents, so that, however similar they may be to O_2Hb, they cannot be accepted as derived from blood unless the spectra of reduced Hb and reduced hæmatin can be obtained in the way described.

Cochineal, colours of certain roots and wood, turn crimson on the addition of ammonia, logwood bluish-black.

The colour of the rose and certain flowers turn green on adding ammonia.

Fruit-stains from mulberry, currants, gooseberries, etc., turn bluish-green with ammonia.

Vegetable stains have their colour heightened by the action of dilute acids.

Chlorine bleaches fruit-stains, but turns the colour of blood-stains to an olive-green.

Red dyes fixed by a mordant are not influenced by ammonia.

Iron stains are usually blackened by ammonium sulphide.

Red paint may contain red oxide of iron; digest with hydrochloric acid and test for iron, by adding ferrocyanide of potassium to obtain the Prussian blue. Iron stains may be of a reddish-brown or orange colour, and insoluble in water, so that HCl is used to dissolve them.

Citrate and malate of iron stains are soluble in water; the addition of ammonia to an aqueous solution produces no change; guaiacum will give a blue reaction if a persalt of iron be present. The addition of hydrochloric acid and ferrocyanide of potassium will give the Prussian blue reaction. A drop of nitric acid added to the solution will oxidise the iron to the ferric state, and on the addition of a few drops of fresh-made

aqueous solution of sulphocyanide of potassium the port-wine colour of sulphocyanide of iron will be produced.

A control test must be made with distilled water to prove the purity of the reagents, and the two results compared with each other.

Aniline stains resembling blood are changed to greenish-yellow or yellow on the addition of dilute nitric acid. Eosin stains produce a fluorescent solution when dissolved in water. Grease, tar, pitch, snuff, and paint may be mistaken for blood, especially on dark fabrics. They may be detected by two methods :—

(*a*) **The Wet Method.**—Having failed to obtain a solution by the aid of the ordinary solvents for blood, other solvents must be used ; ether or benzene for grease, paint, or tar. The solution obtained must be examined with the spectroscope.

(*b*) **The Dry Method.**—Place the cloth or other fabric stain down upon a clean white filter paper ; then on pressing the cloth with a hot laundry iron, grease, tar, or pitch will stain the paper, paint or snuff will not.

CHAPTER VII.

BURNS AND SCALDS, CONTUSIONS AND BRUISES.

BURNS AND SCALDS.

BURNS and Scalds are lesions characterised by a more or less marked destruction of the tissues of the body, caused by the action upon its internal or external surfaces of a temperature higher than that of the body itself, or by the action of corrosive chemical substances.

Burns are produced in the following ways :—

By exposure to radiant heat.

By the direct application of flame.

By contact with heated solids.

By contact with solid bodies which have become liquefied by heat, such as metals in a state of fusion.

By friction.

By lightning and electricity.

By contact with corrosive chemical substances, solid or liquid.

Scalds are produced by the application of heated liquids, at or near their boiling-points, or in a gaseous form as *steam*.

The injuries produced will depend upon the degree of temperature, the period of exposure to its action, and the extent of surface involved.

The danger to life depends more on the extent of surface injured than the intensity of the burn or scald upon a limited area, unless the position of the burn render it peculiarly dangerous. Even though the injuries be comparatively superficial, if they involve one-third or one-half of the surface of the body they must be regarded as fatal. They may prove fatal by shock, by asphyxia, by constant and profuse discharge from the injured surface, from absorption of septic matter, from secondary inflammations of internal organs and serous mem-

branes—pleurisy, peritonitis, meningitis, perforating ulcer of the duodenum. Children succumb more quickly than adults to burns and scalds—the simplest, in their case, often proving fatal.

The cause of early death from burns and scalds is looked upon as a disorder of the blood following injury to the red corpuscles by the heat, and that this is more easily brought about in children, because of the thinness of the skin, and the red corpuscles being less capable of resistance.

The following table gives the different degrees of burns:—

1. Superficial inflammation, characterised by redness without blistering.

2. Acute inflammation, the epidermis raised, forming vesicles containing serum.

3. Destruction of the superficial layers of the true skin.

4. Destruction of the true skin and subcutaneous cellular tissues.

5. The superficial and deep parts converted into a charred mass.

6. Entire carbonisation of the parts.

(Dupuytren.)

Post-mortem Appearances.

These will vary according to the extent of the injuries, the length of time the individual lived after receiving them, and the causative agent.

External Appearances:—

1. *Burns.*—Radiant heat whitens the skin, flames blacken it, from deposit of carbonaceous material. The hair and clothing of the body are singed. Blisters may be present on various parts, and roasted patches of the skin or deeper parts may be present. The flame of an explosive, such as a mixture of coal gas and air, scorches and mummifies the skin. The skin is blackened by the explosion of gunpowder, and particles of the powder may be driven into it; similar results follow explosions in coal-mines, but to a greater degree. Burns caused by red-hot solids or molten metals vary in appearance according to the length of time they have remained in contact with the surface: if short, there may be injury to the skin only, with blistering; if for a longer period, there will be roasting or charring of the part, and blisters may not be present.

All stages of burns may be present.

The uncovered parts of the body, as a rule, are more affected than the clothed, unless the clothes become ignited, when the converse would hold good. In cases where the clothes have been saturated with an inflammable oil like petroleum the burns are much more severe.

2. *Scalds.*—The appearances produced and the severity of the result will vary directly with the boiling-point of the liquid. Boiling water and steam produce vesication; the hairs are not affected. If the steam be superheated, blistering may be absent, and the skin appear sodden and devoid of elasticity. If the person survive the injuries for some days, the skin will present appearances of reaction. After exposure to great heat the bodies of the victims are usually contorted, with the limbs flexed and the arms fixed in a defensive attitude—the "pugilistic attitude." This condition is due to *heat rigidity.*

Internal Appearances.—The brain is shrunk, usually without any alteration in form, the lungs also shrunk, and the larynx, trachea, and bronchi may contain carbonaceous material; their membranes may be injected and covered with frothy mucus. The kidneys may present reddish-brown markings from altered blood, and degeneration of the epithelium of the tubules and malpighian bodies.

There may be a reddened appearance of the mucous membrane of the stomach and intestines, and in a certain number of cases, where death has occurred some time after the injuries, ulcers may be present in the duodenum.

The uterus and testicles resist the action of fire in a marked degree, and may be changed but slightly, although the rest of the body has been almost consumed.

The blood of persons who have been exposed to the action of CO during a fire will present the usual cherry-red colour and the spectrum of COHb. A similar cherry-red colour of the blood is found in bodies of persons burnt to death which is not due to the action of CO. The cause is a physical one, the alteration in colour being due to the coagulation of the albumin in microscopical particles by the heat. In this condition the spectrum is that of O_2Hb, and can be reduced in the usual way. The same peculiar condition of the blood may be produced in corpses by exposure to a sufficiently high temperature.

If on the examination of the blood COHb is detected, it

indicates that the person in whose body it is found was alive during the progress of the fire.

Corrosives.—The appearances produced by the application of corrosive chemical substances are peculiar to them, and depend upon their special actions upon the tissues. Sulphuric acid acts by rapidly extracting water from the tissues and producing local rise of temperature; nitric acid combines with the tissues to form picric acid; nitrate of silver acts upon the tissue by hyperoxidation, and combines to form albuminate of silver, nitric acid being liberated. A solution of phosphorus in carbon disulphide, known as Greek fire, by the rapid oxidation and burning of the phosphorus produces combustion of the tissues.

The diagnosis of lesions produced by corrosives from those by fire or heated fluid or steam rests upon the absence of vesication, the presence of the stains on skin or clothing which they produce, and the chemical analysis of the stains. Sulphuric acid produces a grey or brownish-black eschar on the body; hydrochloric acid may leave a whitish-grey stain; nitric acid produces a yellow stain on the skin, and may produce sloughing.

Was the burn inflicted before or after death?—The answer to this question depends upon careful consideration of all the evidences afforded by the external and internal appearances, and upon the presence or absence of *vital reaction* in the lesions found.

Two characteristic appearances—redness and vesication—are present in burns inflicted during life when the surface of the body is not charred and the tissues destroyed. The redness affects the surface and entire substance of the true skin, which is dotted by the deep red openings of the sudoriferous and sebaceous ducts. This appearance cannot be produced after death. Blisters are formed by a temperature somewhat less than that of boiling water. Vesication, according to Orfila, is characteristic of a burn inflicted during life, and the late Sir Robert Christison found that in burns caused before and after death the vesicles in the former contained serum, the latter air. In anasarcous subjects, however, serous blisters may be formed, especially if the heat employed be not too severe. A case is recorded by Taylor in which vesicles containing bloody serum were formed on the body of a man who had just been drowned and who had been put into a hot bath.

Ante-mortem vesicles in which vital reaction has taken place present the following characteristics :—

(*a*) They contain serous fluid in which albumin and chlorides can be detected.

(*b*) An inflammatory red bounding line round the circumference.

(*c*) Inflammatory redness of the base, and the papillæ of the skin.

(*d*) The presence of pus, which would indicate that the person had lived at least thirty-six hours after the burn had taken place.

In burns produced after death, the surface and substance of the skin is of a dull white colour, dotted with grey openings of the sudoriferous and sebaceous ducts, and the subcutaneous tissues are uninjected. Vesicles produced by burns may have to be distinguished from the phlyctaenae, the result of advanced putrefaction. The latter possesses none of the characteristics of the former.

If a vesicle present the following characteristics it may be accepted as of post-mortem origin without doubt: if it be small and its contents scanty, if the fluid it contains be free from albumin and chlorides, if it contain air, and if there be no signs of inflammatory reaction.

Was the burning homicidal, suicidal, or accidental? No general rules for guidance can be here laid down. In most cases, the conditions under which the body is found will point less to suicide than to homicide or accident. In cases of murder, the body is often burnt to destroy all traces of the crime. It must, however, be borne in mind that intense heat applied to the body may give rise to a wound on the surface like that caused by a cutting instrument. Casper mentions such a case, in which a wound was found over the liver, due to the application of intense heat to the body. The conjunction of robbery will greatly assist in helping to solve the difficulty. It may be very confidently stated that to dispose of a body by burning is no easy matter.

Preternatural Combustibility.

The possibility of "spontaneous combustion" occurring in bodies during life has been mentioned in the earlier writings

on medical jurisprudence, and cases have been recorded in which it has been alleged to have taken place. Up to the present time no undoubted case of "spontaneous combustion" during life has been seen; on the other hand, the possibility of its occurrence is contra-indicated by the following facts: that the human body must consist of 75 per cent of its weight of water, to be compatible with life, and that a dead body steeped in methylated spirit for many months or even years will never be consumed, if set on fire, in the rapid and complete manner alleged as occurring in cases of so-called "spontaneous combustion."

A case is recorded by Beatson (*B. M. J.* vol. i. 1886, p. 295) of a man, subject to foul eructations from the stomach, who got out of bed during the night and struck a match to see the time; while blowing out the light his breath took fire, producing an explosive noise sufficiently loud to awaken his wife. Such cases are very rare.

It is a fact that by the action of certain micro-organisms upon organic matter inflammable gases are produced. That such an occurrence is possible, in the dead human body, is supported by cases recorded by Gull (*Med. Times and Gazette*, 1885) and Reynolds (*Med. Chron.* 1891). In Gull's case inflammable gases escaped through punctures made into the abdomen, and they burned spontaneously on contact with the air. In Reynolds's case no flames were seen, but extensive and deep marks of burning were present, especially on the trunk and thighs. It has been suggested that the habitual use of alcohol in excess during life renders the tissues of the body more inflammable, but the matter is not yet decided. Tissues steeped in alcohol are not rendered more inflammable.

Dr. Ogston, who cautiously avoids committing himself to the belief in "spontaneous combustion," yet thinks that the subject of *preternatural combustibility* in certain conditions of the body may perhaps, to say the least of it, be set down as one still *sub judice*. "There is no evidence to justify the use of the word 'spontaneous,' but there can be no doubt that an extraordinarily high degree of combustibility occurs in rare instances, to which the term *preternatural* combustibility would more correctly apply" (J. Dixon Mann).

CONTUSIONS AND BRUISES.

In the living these injuries are accompanied with swelling, pain, and more or less discoloration of the part affected. Among malingerers it is not an uncommon practice to bruise the body to imitate the spots of purpura and scurvy. In scurvy, the condition of the gums common to that disease, and the state of the general health, will point to the true nature of the spots. The diagnosis of purpura will be assisted by noting the diffusion of the spots over the body. In old people purpuric spots frequently extend round the limbs, chiefly on one of the lower extremities. Some persons are very easily bruised, and a pinch, by no means severe, will cause on their arms a severe bruise. Discoloration —ecchymosis— may take place in the skin, cellular tissue, muscles, or internal organs as a result of external injury, or it may be due to sudden and powerful contraction of a muscle or group of muscles. Not infrequently the discoloration does not appear over the seat of injury, but at some distance from it; and when the effusion is deep-seated, days may elapse before any discoloration of the skin takes place, and then it is not blue, as in superficial parts, but of a violet, greenish, or yellowish hue. A deep-seated ecchymosis may give no external sign of its presence; hence in all cases deep incisions should be made before an opinion is ventured as to the entire absence of this occurrence. This is very noticeable among the deep-seated muscles of a limb. In these cases, forty or fifty days may elapse before the deep-seated bruise shows its existence on the surface, and then only as irregular, yellowish, green, or bluish spots over the part. A very slight contusion, as a sprain of the ankle, may give rise to extended discoloration up the leg. An ecchymosis is not necessarily situated directly under the seat of injury. A blow given during life may not appear as an ecchymosis till *after death*. The change of colour in bruises begins at the circumference, and travels inwards. During the first three days the colour of the bruise is blue, bluish-black, or black; greenish on the fifth or sixth day; and yellow from the seventh to the twelfth. The extent of an ecchymosis depends greatly on the looseness of the cellular tissue. A slight contusion causes a slight redness and swelling, and may leave no mark on the dead body, unless death has

taken place within thirty-six hours. Injuries of this kind sometimes leave a parchment-like hardness and discoloration of the skin. The part looks slightly depressed, due probably to the epidermis having been partly rubbed off, and the skin then drying. Similar marks are sometimes made by blisters. These marks may be produced on the dead body by friction and exposure to the air.

The diagnosis of ecchymosis from hypostasis has been given (see p. 47). It appears also that a slight blow inflicted before death would require a tolerably severe one after death to produce like appearances. In scourging, there are parallel ecchymosed lines, or small spots resembling petechiæ. An internal organ may be ruptured, and yet there may be no appearance of injury externally. The liver is most commonly ruptured. The rupture is almost always longitudinal, and in some cases a portion of the gland is more or less detached. The spleen is also not infrequently ruptured; and this occurs most frequently in countries where ague prevails. Rupture of the lungs and brain is rare. When the pelvis is fractured, the bladder is frequently found ruptured.

Death in most cases is due to internal hæmorrhage or shock, when any of the internal organs are ruptured.

Can the appearance of a bruise be produced after death?—It is possible that the appearance of a bruise inflicted during life may be produced within two hours after death, and in some rare cases even after the lapse of three hours and a quarter; but these ecchymoses are limited in extent, and when large are due to a rupture in a vein which can be readily ascertained. The experiments of the late Sir Robert Christison, relating to this question, are detailed in the *Edinburgh Medical and Surgical Journal*, vol. xxxi. After reading the account of these experiments, it seems to me that the amount of violence required after death to produce appearances like those made before death is such as would seldom, if ever, be inflicted on a corpse, and, therefore, where we find a well-marked bruise we ought to infer that it was made before death.

The following Table, compiled from the experiments of Christison, may assist the diagnosis:—

During Life.	After Death.
1. Swelling of the part.	1. No swelling.
2. Coagulation of the blood effused into the adjacent cellular tissue, with or without tumefaction.	2. No such appearance, unless there is a rupture of a large vessel in the neighbourhood of loose cellular tissue.
3. Incorporation of blood with the whole thickness of the true skin, rendering it black instead of white.	3. No such appearance produced by a blow after death.

N.B.—Extensive effusion may occur without affecting the skin, but when the skin is so affected Christison thought it decisive of *ante-mortem* injury.

The Size and Form of a Bruise should be noted.

Why?

1. *In Hanging and Strangulation.*—The mark due to pressure of the cord on the neck in hanging runs obliquely round the neck; in strangulation, the mark encircles the neck. The mark is frequently interrupted, and may present very varied appearances in different parts of the neck. The mark of the knot may be found under the chin.

2. *In Throttling.*—The pressure exerted on the throat of the deceased by the fingers of his assailant may leave marks which may point to the means used to cause death.

3. *In other Cases of Death by Violence.*—The impression made by the weapon used may lead to the identification of the murderer. The marks left by the wards of a large door-key once led to the identification of the assailant.

CHAPTER VIII.

SUFFOCATION, HANGING, STRANGLING, AND THROTTLING.

SUFFOCATION.

DEATH from suffocation is said to result from any impediment to the respiration which does not act by compressing the larynx or trachea.

Suffocation may therefore be caused by pressure on the chest, as in persons crushed in a crowd. It may also be due to the respiration of certain gases, or to the presence of pulverulent substances in the air, which act by choking up the air-passages. Imprisonment in any confined space may cause death from suffocation, and abscesses bursting into the trachea, or vomited matters in drunken persons lodging in the windpipe, may be attended with a like result. Pressure on the umbilical cord whilst the child is in the maternal passages causes death from suffocation.

Signs of Death by Suffocation.—The first effect of arrest to the passage of air into the lungs is the stagnation of blood in the capillaries of the lungs. Non-arterial blood then goes to the brain, and consciousness is soon lost. The respiratory sensation is then arrested by the circulation of venous blood. The left side of the heart becomes emptied, and then weak; the right side full and engorged. The great venous trunks are also more or less full, and the abdominal viscera, liver, spleen, and kidneys, congested. The arrest of the heart's action is a secondary effect; the right side is paralysed by being too full, the left by being empty. These signs may be said to be typical, or, rather, are to be expected in death due to suffocation, but it must be distinctly stated that

they are not always present. The right side of the heart is not in all cases engorged with blood; and Christison warns medical men against expecting "strongly marked appearances in every case of death from suffocation." The heart, moreover, continues to contract after the lungs have ceased to perform their duty. Death is thus due to apnœa—that is, death beginning at the lungs—and not to syncope. Death in some cases is from neuro-paralysis or nervous apoplexy. In death by shock, which in most cases is instantaneous, both sides of the heart are equally filled. Death, the result of disease, may present all the signs of death from suffocation, and no suspicion may be aroused as to the cause of death from the *post-mortem* appearances, especially if putrefaction have set in.

The following Table is given as an aid to diagnosis in this form of death:—

Points to be noticed in forming a Diagnosis of Death by Suffocation.

1. *The Blood.*—There is *unusual fluidity* of the blood found in death by suffocation, however produced. This condition is sometimes present in deaths due to certain diseases, fevers, etc., and in cases of narcotic poisoning. Even with the blood in this condition, the presence of coagula in the cavities of the heart is not infrequent. The colour of the blood is changed to a dark purple, but in suffocation by carbonic oxide it is red.

2. *Animal Heat.*—In persons who have died from suffocation the animal heat is long retained.

3. *Cadaveric Rigidity.*—Other things being equal, the *rigor mortis* is as well marked in this kind as in other forms of death.

4. *The Lungs.*—Hyperæmia of the lungs is rarely absent. In most cases both lungs are engorged in about equal proportions. Hypostasis —*post-mortem stains*—must not be mistaken for capillary engorgement.

5. *The Heart.*—Engorgement of the right side of the heart, the left being empty, or nearly so. It is advisable always to examine the heart first, and then the lungs. The pulmonary artery is also much congested.

6. *Capillary Ecchymoses.*—These appear as purplish-red spots on the pulmonary pluræ, on the surface of the heart, aorta, and even on the diaphragm. They may appear on the above-mentioned parts in a fœtus suffocated *in utero* by pressure on the cord. These ecchymoses are rarely seen on adults, most frequently on infants, due probably to the thinness of the coats of the capillaries, which are ruptured in the efforts made to breathe. They are not a positive sign of death from suffocation, as they have been seen in death due to cholera, typhus, and other diseases. They are present also where death is due to hanging, drowning, etc.

7. *Condition and Appearance of the Trachea.*—The mucous membrane

of the trachea is injected, and appears of a cinnabar-red colour. This is present in every case of death by suffocation, and must not be confounded with the dirty cherry-red or brownish-red coloration due to putrefaction. Remember also that the trachea putrefies early. If suffocation be slowly produced, a quantity of frothy mucus may be found in the windpipe, and also in the smaller tubes of the lungs. Always examine, especially in cases of supposed infanticide, the trachea for foreign bodies, the presence of soot, etc. The presence of sand, ashes, etc., in the œsophagus and stomach in persons buried in these mat rials, is presumptive of the person having been placed in them prior to death.

8. *Kidneys, Vena Cava, etc.*—The quantity of blood in the kidneys is always considerable. The abdominal veins are all more or less congested, and the external surface of the intestines presents numerous traces of venous congestion.

9. *The Brain.*—Apoplexy of the brain, as secondary to the pulmonary apoplexy, may be more or less present, attended by its well-known appearances.

10. *Face, Tongue, and Mouth.*—The expression of the face is not characteristic of death by suffocation, and differs in no particular from that common to other forms of death, being more frequently pale than turgid; and the starting of the eyes, popularly ascribed to this form of death, is not often seen. The tongue may or may not be protruded beyond the teeth. The presence of *froth* about the mouth is not constant, and is of common occurrence in those dying from natural causes.

Was the suffocation homicidal, suicidal, or accidental?—Suffocation may occur accidentally during the act of swallowing, and by foreign bodies placed carelessly in the mouth and then forced suddenly into the windpipe. Examine the lips for the presence of ecchymosis and other marks of violence. A man, some years ago, was accused of having caused the death of his wife by strangulation, for which he was indicted, and tried before the High Court of Justiciary in Scotland. The *post-mortem* examination revealed the cause of death as due to suffocation, and the following injuries were found on dividing the windpipe, which contained a quantity of frothy mucus: in the interior of the larynx there was a considerable extravasation of blood lying beneath the investing membrane, and passing up on both sides and behind, as far as the chink of the glottis, or orifice by which air is admitted into the windpipe, and above that opening into the ventricles of the larynx. There was here, also, a fracture of the right wing of the thyroid cartilage, by which its lowest horn was wholly detached, and the cricoid cartilage was broken in two places at opposite sides of its ring. The defence was that she had fallen accidentally while in a state of drunkenness, and had thus produced the fatal injuries.

The man was acquitted, the legal opinion in favour outweighing the medical opinion against the theory of accident. The above case created some discussion at the time, and induced Dr. Keiller to make several experiments as to the possibility of fracturing the cartilages of the larynx. The following are his conclusions :—

1. That *ordinary* falls on the human larynx are apparently not capable of producing fractures of its cartilage, and even *falls from a height with superadded force* appear to be unlikely to do so.

2. That *severe pressure applied from before backwards*, so as strongly to compress the larynx against the vertebral column, or *violent blows inflicted over the larynx by means of a heavy body*, are sufficient to cause fractures of the larynx. Fractures so produced, however, will be most discernible on the *internal* (or posterior) surface, and generally *in or near the mesial line.*

3. *Violent compression* applied to the *sides of the larynx* (as in ordinary *manual throttling or strangulation by grasping*) is, of all applied forces, the most likely to produce fractures of the alæ of the thyroid cartilage, or even of the cricoid cartilage, and fractures so produced are most perceptible, as well as most extensive, on the *external* (or anterior) surface of the larynx. By this *lateral* mode of applying force, the *hyoid bone* is also most readily broken.

4. That the condition of the larynx in regard to the absence or presence of ossific deposit materially influences its liability to fracture from external violence. If altogether cartilaginous, partial slits or splittings may be produced. If partly ossified, fractures may be produced by a comparatively moderate degree of applied violence, and if extensively or entirely ossified, extreme violence will generally be required to produce laryngeal fracture (*Edinburgh Medical Journal*, 1855-56).

In France a favourite mode of committing suicide by suffocation is the use of irrespirable gases—carbonic acid, carbonic oxide, and the like. Collateral circumstances must be taken into consideration, and will more or less help to point to the true cause of death.

The cause and nature of the death in all of its forms just mentioned are in general the same. Pressure on the trachea thus arresting respiration and also on the important vessels and nerves of the neck, results in death, which may be brought about in four different ways :—

1. Cerebral congestion, or apoplexy.
2. Congestion of the lungs and heart apnœa or asphyxia.
3. Combination of above apoplexy and asphyxia or apnœa.
4. Neuro-paralysis—nervous apoplexy, or syncope.

The following Table will show the relative frequency of each form of death :—

	Remer.	Casper.
Apoplexy	9	9
Asphyxia	6	14
Mixed	68	62
	83	85

HANGING AND STRANGULATION.

Hanging.—Death by hanging is caused by the more or less perfect suspension of a body by a cord applied round the neck, the weight of the body acting as the constricting force.

Strangling.—Death due to pressure made on the neck by any form of ligature carried circularly round the neck. The cord in hanging is as a rule placed more obliquely than in strangulation.

Death may occur in any of the forms above stated. Sensibility is soon lost, and death rapid. The external appearances are more or less those described under "Death from Suffocation." In the greater number of cases the face bears a quiet, placid expression, no turgidity or lividity being noticeable. The eyes are not protruded. The tongue does not hang out of the mouth, nor is it bitten by the teeth. This accords with the account given of the appearance of the face of the murderer Peace hanged at Leeds.

Turgescence of the male and female genitals is said by some to take place. Casper states that in not one of the many cases he had examined of persons hanged has he ever "found an erection of the male organ," and he also asserts that the emission of semen is extremely rare. Seminal emissions take place more frequently in persons who have been shot, and also in those who have been poisoned by irrespirable gases or by hydrocyanic acid. As a test of strangulation, it is therefore worthless. The escape of urine or fæces may occur. Tardieu, however, only noticed it in two out of forty-one cases; it is by no means a test of hanging, as it may occur after death if the body is shaken in a cart, or roughly used when first found. A fat person dying of apoplexy may have a mark round the neck as if strangled. Injury to the spinal cord due to fracture or dislocation of the cervical vertebræ is rare in suicidal hanging. Fracture of the spinal ligaments and of the hyoid bone is also

rare. Rupture of the internal and middle coats of the carotid arteries sometimes occurs. But it appears that considerable damage is done to the soft parts of the neck by the present judicial mode of hanging with the "long drop."

Dr. Dyer has recorded (*New York Medical Journal*, vol. iii. 1866) some experiments he made on the eyes of a man and some dogs killed by hanging. He found certain transverse fissures across the lens, which he is inclined to think are characteristic of this mode of death. Dr. R. F. Hutchinson states that an invariable sign of death from hanging is *the flow of saliva out of the mouth, down the chin, and straight down the chest.* The appearance is unmistakable and invariable, and *could not occur in a body hung up after death*, the secretion of saliva being a living act (CHEVERS). Death from hanging may take place although the toes or other parts of the body rest on the ground. Death is complete in four or five minutes.

Marks of the Cord, etc.—The mark of the cord is nearly always present, but is often interrupted, sometimes only seen on one side. In strangling, the mark is low down, most frequently encircling the neck; in hanging, the mark is generally above or on the thyroid cartilage, and carried obliquely upwards. The mark of the cord may be of a dirty yellowish-brown colour, and, when cut into, feels more or less hard and leathery. In general appearance it is not unlike the mark left by mustard plasters or blisters applied within a short time of death. This effect is probably produced by the rubbing off of the epidermis, and subsequent drying up of the cutis on exposure to the air. At other times the mark may be of a dirty-reddish or bright-blue colour; or, lastly, there may be little or no mark present, or the edges may assume a livid red coloration, being nothing more or less than a *post-mortem* stain.

THROTTLING.

Throttling.—Death due to the constant pressure of the fingers on the throat.

The marks left by the act of throttling are similar to those produced by hanging and strangulation, only differing in form. The impressions of the fingers are upon opposite sides of the throat, and are more or less separated. The skin presents at times the parchment-like appearance just described, with slight

ecchymosis under the patches. The impressions left by the nails may sometimes be seen.

May the mark of the cord be produced after death?—On this point Casper says: "That any ligature with which any body may be suspended or strangled, not only within a few hours, but even days after death, especially if the body be forcibly pulled downwards, may produce a mark precisely similar to that which is observed in most of those hanged while alive." And the same authority also adds that "the mark of the cord is a purely cadaveric phenomenon."

Suicide or Homicide?—The answer to this question must be framed in accordance with the history of the case and the attendant circumstances under which the body was found.

Homicidal hanging is so rare as scarcely to require notice, and it also presupposes a considerable amount of strength on the part of the assailant to accomplish his purpose.

Suicidal hanging—a favourite mode of death with suicides—is common enough. The absence of marks of injury on the body found suspended, and the want of evidence as to a previous struggle having taken place, all point to suicide. Throttling is never suicidal; strangulation may or may not be the act of a suicide, but the evidence is in favour of homicide.

It must also be remembered that murderers not infrequently suspend their victims after death, to give an air of suicide to the transaction. The presence of considerable injury about the neck militates greatly against the possibility of suicide. In all doubtful cases, therefore, the stomach should be examined for poison, and the body for bruises, which latter may, however, be inflicted by the suicide on himself in his struggles before death ensues. The fact that the feet are found in contact with the ground does not militate against the probability of suicidal hanging; and it appears that in India the natives seldom hang themselves from any height, and are most frequently found with their feet on the ground.

CHAPTER IX.

DROWNING.

Death by drowning occurs when the breathing is arrested by watery or semi-fluid substances, blood, urine, or the muddy semi-fluid matter found in cesspools and marshes. It is not necessary for the whole body to be submerged. Death may result if the face alone be immersed, as in the case of a man in a fit of drunkenness being drowned in the water contained in the imprint of a horse's hoof left in the mud.

In addition to the changes in the internal organs, identical with those present in persons who have died from suffocation or hanging, water is found in the lungs or stomach.

Death may be due to—

(*a*) Apoplexy. (*b*) Asphyxia. (*c*) A combination of the two. (*d*) Neuro-paralysis.

Death from pure apoplexy is rare; and it may be affirmed that death from syncope never occurs in the drowned without leaving some of the signs of asphyxia. Is it not a little absurd, to describe death from syncope, even in the case of bodies found in the water, as due to drowning?

It is more difficult to restore the drowned than those dying from mere stoppage of air from entering the lungs. Few if any persons recover who have been submerged four minutes, and even in cases where this time has been exceeded, followed by recovery, this result is probably due to the person fainting before entering the water.

In death from drowning, the lungs are distended and overlap the heart, and have a peculiar spongy feel. They also contain a quantity of frothy fluid, which cannot be produced in the dead body, as it is the result of the violent efforts made

by the individual to breathe in the act of dying. This frothy condition of the fluid in the lungs is an important sign of death by drowning, especially if the fluid corresponds with that in which the individual is said to have perished. It is just *possible*, however, that the person may have been first suffocated, and then thrown into the water, froth in the trachea being found in those suffocated ; but in this case the froth is small in quantity, and not watery. The froth in the drowned is like that made with soap in water, and is not viscid, thus differing from bronchitic exudation. Water in the stomach is an important indication of death from drowning, especially if the water contained in the stomach can be shown to possess the same characters as that in which the body was found. In a great number of cases this, however, must be next to impossible ; when it can be identified, the value of this sign is enhanced by the fact that water does not enter the stomach in those submerged after death, unless putrefaction be far advanced, or the body has lain in very deep water. Casper concluded that a person had been drowned, by finding a small quantity of mud in the stomach after putrefaction had set in. Water, however, may be absent from the stomach if the person fall into the water in a state of syncope, and it may be present if the person have taken a draught of water before submersion.

The effect of season on putrefaction in water is shown in the following Table :—

Summer.			Winter.
5 to 8 hours	produce as much	change as	3 to 5 days.
24 ,,	,,	,,	4 to 8 ,,
4 days	,,	,,	15 ,,
10 to 12 ,,	,,	,,	28 to 42 ,,

(DEVERGIE.)

Of the external signs, the presence of sand, gravel, or mud under the nails may or may not be an important sign, for sand or mud may collect under the nails during the efforts to drag the body from the water ; but weeds, etc., grasped in the hands show that there has been a struggle, and point to death from drowning. The *cutis anserina*—goose skin—present generally on the anterior surface of the body, and not, however, peculiar to death from drowning, is important as a sign of recent vitality. The face of those who have been drowned, and then quickly removed from the water, is pale, and in most

cases not swollen; the eyes may or may not be closed; and not infrequently round the mouth there is more or less froth, especially when death is due to apnœa. In summer, however, after two or three days, and longer in winter, the face assumes a reddish or bluish-red coloration, putrefaction taking place about the head and upper extremities earlier than in other forms of death. The *contraction or retraction of the penis* is a well-marked sign of death by drowning, and Casper asserts that he has "not observed anything similar so constantly after any other kind of death." Ogston states that he has met with two cases of erection of the penis in the drowned.

The question as to how long a body may remain in the water before it floats has given rise to considerable discussion, without, however, arriving at any very definite conclusion. It may be stated in general terms that, as floating depends to some extent on the rapidity in which putrefaction supervenes on submersion, bodies float earlier in summer than in winter, in salt than fresh water, clothed than naked. In India bodies have floated in twenty-four hours after immersion. Females and children float more readily than males. A body from various causes may float within a few hours of its submersion, especially if the body be that of a female, fat and clothed. The old idea that the body of a person thrown into water during life sinks, but that a dead body under like conditions floats, is a fiction now exploded.

Suicide or Homicide?—Homicide by drowning is rare, except in children. Accidental and suicidal drowning are common enough.

The signs to be sought for in the drowned are—(1) Absence of any injury. (2) *Cutis anserina* and retracted penis. (3) Water and mud in the stomach. (4) Froth in the air-passages. (5) Distended lungs. (6) General signs of death by asphyxia.

It should be remembered that the fact of the hands being tied together, or to the feet, does not militate against suicide by drowning.

If wounds and other injuries be found on the body, the question arises as to whether the injuries were sufficient in themselves to cause death, and then as to whether they were caused during life. A person jumping from a height into the water may sustain severe injuries—dislocation of both arms, fracture of the skull and of the vertebræ, or even

lacerated wounds of more or less severity. The absence of the signs proper to death by drowning, coupled with the presence of external injuries, would point to death by violence prior to immersion.

The following considerations may assist in forming an opinion :—

1. Previous history of person found in the water.
   (*a*) Any history of suicidal tendency.
   (*b*) Any motive that would render suicide probable.
2. Height from which the person fell.
3. Absence or presence of signs of death by drowning.
4. Absence of stakes or other objects in the water that might have caused injuries to any one falling against them.

The time required to cause death by drowning is so short that persons seldom recover after submersion for three or four minutes ; but the cessation of respiration is no guide to the extinction of life, and an attempt at resuscitation should always be made, for if the respiration be fairly restored the heart will soon act. Nay more, as pointed out before, in cases of so-called asphyxia, the heart may continue to act for several minutes after the entrance of air to the lungs has been arrested, and in judicial hanging it frequently happens that the pulse at the wrist can be felt for ten or twelve minutes after suspension.

Recapitulation of the Post-mortem Appearances in the Drowned.

I. External.

1. *In the Skin.*—The condition of *goose skin—cutis anserina*—is hardly ever absent, even in summer. The *cutis anserina* is not, however, characteristic of drowning, as it may be present in other forms of violent death, and also in some persons during life. It is a vital act, the result of nervous shock, and does not depend upon the temperature of the water for its production ; still, it points to recent vitality.

2. *The Tongue.*—The tongue is just as often found behind the jaws as between them (Casper).

3. *The Hands and Feet.*—The hands and feet acquire a greyish-blue colour when the body has lain in the water from twelve to twenty-four hours. The skin also becomes corrugated in longitudinal folds. The greyish-blue condition of the hand is known as the "cholera hand." The nails may contain particles of sand and weeds. "No corrugation or discoloration of the skin of the hands or feet is ever observed on the body of any one drowned who has been taken out of the water within

half an hour, within two, six, or even eight hours" (CASPER). The same authority states he has produced these effects by laying the hands after death in water, or wrapping them in cloths kept constantly wet for a few days.

4. *The Genitals.*—Contraction of the penis is an almost constant symptom, and Casper has "not observed anything similar so constantly after any other kind of death." It is due, probably, to the same cause as the *cutis anserina*, which Brettner attributes to "bundles of unstriped muscular fibres, lying in the upper stratum of the true skin, surrounding the sebaceous glands, and forcing them forwards by their contraction, thus making the *cutis anserina.* Precisely similar unstriped muscles are found in the subcutaneous cellular tissue of the penis; they run principally parallel to the long axis of the member, but very often large bundles run across it." The action of cold and fright is to induce contraction of these cutaneous muscles, with a resulting contraction of the penis.

II. INTERNAL.

1. *The Brain.*—Cerebral hyperæmia is *most* rare in the drowned, but cerebral hypostasis is not infrequently mistaken for it.

2. *The Trachea.*—The mucous membrane of the trachea and larynx is always more or less injected, and is of a cinnabar-red, which must not be mistaken for the dirty brownish-red colour, the result of putrefaction. A white froth, but seldom bloody, is also found in varying quantity in the trachea, and is a most important sign of vital reaction, but its diagnostic value is destroyed by putrefaction. Sometimes a portion of the contents of the stomach may be found in the trachea. When this occurs it is due to the act of coughing, induced by the admission of water into the lungs. The contents of the stomach are forced into the mouth, and then drawn into the lungs during the next attempt at inspiration. This indicates that the person entered the water during life. In cases where death has taken place from syncope little or no froth may be found in the trachea.

3. *The Lungs.*—The lungs are completely distended, almost entirely overlapping the heart, and pressing close to the ribs. They are spongy to the feel, and when cut into, a considerable quantity of bloody froth escapes. The *froth* found in the lungs is the result of the powerful attempts to breathe, and cannot be produced by artificial means. It adheres not to the sides of the bronchial tubes, as does the exudation of bronchitis or pneumonia. The distension of the lungs is due partly to an actual hyperæria, partly to inhaled fluid, and partly to hyperæmia.

4. *The Heart and Great Vessels.*—As is common to other forms of asphyxia, the left side of the heart is entirely, or almost entirely, empty; the right, on the contrary, is engorged. This condition of the heart is, therefore, not a diagnostic sign of drowning, and is absent in the drowned when death takes place by neuro-paralysis; in fact, in some cases of undoubted drowning, both sides have been found empty, probably, however, the result of putrefaction (OGSTON). The same may be said of the accompanying congestion of the pulmonary artery.

5. *The Blood.*—As is common in all forms of death where respiration has been arrested, the blood is found to be remarkably *fluid*, and of a

cherry-juice colour. M. Faure in his monograph on asphyxia states that he has found large and firm clots in the right side of the heart in the drowned who have not remained long under water.

6. *The Stomach.*—Casper considers that the presence of fluid in the stomach, corresponding to that in which the body is found, is "an irrefragable proof of the actual occurrence of death from drowning," and that the swallowing of it must have been a vital act of the individual dying in the water.

N.B.—Putrefaction in the drowned in most cases commences in the upper part of the body, and extends downwards. The face, head, and neck are first attacked. This is the reverse of putrefaction in air.

CHAPTER X.

DEATH FROM STARVATION, COLD, BY LIGHTNING —SUICIDE.

DEATH FROM STARVATION.

Death from starvation may occur during famines, amongst shipwrecked sailors and persons entombed in mines or pits, and is due to sheer privation. It may follow criminal starvation; as a result of wilful refusal to take food, as a form of suicide, it has been noted in cases of hysteria and lunacy. Death from starvation may result from mechanical hindrance to the entrance of food into the body or its passage through the alimentary tract, such as ankylosis of the jaws, stricture of the œsophagus or stomach from cancer, or cicatrisation after injury from swallowing corrosive substances. Amongst other diseases, tuberculosis and diabetes mellitus are the chief which produce external appearances of starvation.

Death from starvation may be classed as *acute* when it occurs within fourteen days from the withdrawal of food, *chronic* when at a later period.

Symptoms of Starvation.—The body-temperature falls below normal, after a varying period of feverishness, and the fall may be two or three degrees below normal before death. The pulse gradually increases in frequency day by day. The chief sign is loss of body-weight. Chossat's experiments on pigeons showed that when they were totally deprived of food, the surplus fat of the body was lost first, then the fatty coverings of internal organs, the interstitial fat of muscles last of all; the muscles themselves also wasted. A peculiar odour emanates from the bodies of those who have died from starvation.

In addition to the above signs, there are anæmia, sunken, glistening eyes with dilated pupils, prominence of bony pro-

jections, pale and dry lips and tongue, parched mouth and throat, weakness of the voice, sunken abdomen, wasted limbs, constipated bowels, urine scanty and turbid. There are pains in the abdomen, relieved by pressure, great thirst, a dusky, dry skin, exhaustion, ultimately delirium ending in death.

Post-mortem Appearances.—There is emaciation of the whole body, dry, wrinkled skin of a brown colour; the muscles are flabby and wasted, the abdomen sunken, the eyes red and open; this appearance is not common in death from other causes. The mouth and throat are dry even to aridity. The heart, lungs, and blood-vessels are collapsed, and contain but little blood. The abdominal viscera are shrunken and without enveloping fat. The omentum is devoid of fat, and clear; the gall bladder is full of dark bile; the urinary bladder may be quite empty. The stomach and intestines are collapsed, contracted and empty, and the walls extremely thinned.

Diagnosis.—The absence of any other cause for death—such as cancer of the stomach, stricture of the œsophagus, etc.—and the previous history of the case will assist in forming an opinion, care being taken not to confound the results of wasting disease with those due to starvation.

Legal Relations.—The question of death from starvation may be raised in a case of infanticide by omission. Although rare as an act of homicide, it must be remembered that the law does not require the absolute deprivation of food to be proved, but only that the necessary quantity and quality of food has been withheld; but malice at the same time must be proved. In cases of infanticide by starvation, the mother and not the father is responsible for the proper feeding of the child; but in the case of an apprentice, the master and not his wife is bound to supply proper food to such apprentice.

In questions of survivorship, and in criminal cases, the medical witness may be asked how long a person may survive after complete withdrawal of food. Little is known as to the length of time required to cause death by starvation, but it is certain that life may be prolonged for some time without food, if water be allowed. In a case recorded in the *Lancet*, a man who had been shut up in a coal-mine for twenty-three days, with only a little dirty water to drink, lived three days after his liberation, and then died of exhaustion. In adults the average is from seven to ten days without water. Tidy

(*Legal Medicine*, vol. i. p. 392) is of the opinion that the young die first, then adults, and the aged last. Taking into account the enfeebled vitality of the aged, it is more probable that the young or middle-aged adult would survive the longest. Where water is freely obtainable, life may be prolonged to the fifty-eighth day (*Foderé*, vol. ii. p. 276).

Apart from age, account must be taken of the condition of the person in reference to bodily health prior to the withdrawal of food.

The following Tables, showing the average weight and height of children up to twelve years of age, are from the Report of the British Anthropometric Committee (1883).

MALE CHILDREN.

Age.	Height.	Weight in Pounds.
At birth	...	6·8
One month	...	7·4
Two months	...	8·4
Three ,, ...	...	9·6
Four ,, ...	...	10·8
Five ,, ...	...	11·8
Six ,, ...	...	12·4
Seven ,, ...	...	13·4
Eight ,, ...	...	14·4
Nine ,, ...	...	15·8
Ten ,, ...	...	16·8
Eleven ,, ...	...	17·8
Twelve ,, ...	...	18·8

Age.	Height in Inches.		Weight in Pounds.	
	Female.	Male.	Female.	Male.
One year . . .	27·5	33·50	...	18·8
Two years . .	32·33	33·70	25·3	32·5
Three years . .	36·23	36·82	31·6	34·0
Four ,, . .	38·26	38·46	36·1	37·3
Five ,, . .	40·55	41·03	39·2	39·9
Six ,, . .	42·88	44·00	41·7	44·4
Seven ,, . .	44·45	45·97	47·5	49·7
Eight ,, . .	46·60	47·05	52·1	54·9
Nine ,, . .	48·73	49·70	55·5	60·4
Ten ,, . .	51·05	51·84	62·0	67·5
Eleven ,, . .	53·10	53·50	68·1	72·0
Twelve ,, . .	55·66	54·99	76·4	76·7

Table of Ages, Heights, and Weights of Males and Females from 13 to 30-35 Years of Age.

Years of Age.	Males.		Females.	
	Height in Inches.	Weight in Pounds.	Height in Inches.	Weight in Pounds.
13	56·91	82·6	57·77	87·2
14	59·33	92·0	59·80	96·7
15	62·24	102·7	60·93	106·3
16	64·31	119·0	61·75	113·1
17	66·24	130·9	62·52	115·5
18	66·96	137·4	62·44	121·1
19	67·29	139·6	62·75	123·8
20	67·52	143·3	62·98	123·4
21	67·63	145·2	63·03	121·8
22	67·68	146·9	62·87	123·4
23	67·48	147·8	63·01	124·1
24	67·73	148·0	62·70	120·8
25-30	67·80	152·3	62·02	120·0
30-35	68·00	159·8	61·15	120·8

Recapitulation of the Post-mortem Appearances of Death by Starvation.

1. *In the Body generally.*—Marked general emaciation of the body. The skin is dry and shrivelled, sometimes more or less covered with unhealthy-looking pimples, the muscles soft, reduced in size, and free from fat. A peculiar fœtid acrid odour is given off from the body.

2. *In the Solid Viscera of the Thorax and Abdomen.*—The liver is small, the gall bladder puffed with bile, and the heart and kidneys deprived of any surrounding fat. All the internal organs are shrivelled and bloodless.

3. *In the Stomach and Intestines.*—The stomach in some cases is quite healthy, but more or less stained with bile ; in others it is found collapsed, contracted, empty, and the mucous membrane more or less ulcerated. The intestines are thin, contracted, empty, and so shrunken that the canal is almost obliterated. According to the late Dr. Duncan, the intestines are frequently found inflamed and ulcerated.

DEATH FROM COLD.

This form of death is rare in England, but is more common in countries where the winters are severe. Anything that depresses the vital powers renders the individual more or less amenable to cold ; such, for instance, as drunkenness, previous illness, or deficiency in the amount of food. The following

post-mortem appearances are given by Ogston, who holds that they point, in the absence of any other obvious cause of death, "if not with absolute certainty, yet with high probability," to death caused by cold :—

1. An arterial hue of the blood generally, except when viewed in mass within the heart ; the presence of this coloration not having been noted in two instances.

2. An unusual accumulation of blood, as in Quelmalz and Cappel's cases, on both sides of the heart, and in the larger blood-vessels of the chest, arterial and venous.

3. Pallor of the general surface of the body, and anæmia of the viscera most largely supplied with blood. The only exceptions to this were moderate congestion of the brain in three cases, and of the liver in seven of them.

4. Irregular and diffused dusky-red patches—"frost erythems"—on limited portions of the exterior of the bodies, encountered in non-dependent parts, these patches contrasting forcibly with the pallor of the skin and general surface.

These signs are not so well marked in children as in adults. The late Sir Benjamin Brodie considered that the effect of cold is to destroy the principle of vitality equally in every part, and that it does not exclusively disturb the functions of any particular organ. The fact of a body being found frozen is no proof that death has been brought about by cold.

Diagnosis.—The general appearance of the deceased, and the absence of any other cause of death, together with the appearances just mentioned, will assist in forming an opinion on this difficult subject. The body lies as if in a deep and calm sleep, without any external appearance to guide us as to the cause of death, except perhaps a swelling of the extremities, which has come on prior to death. If a body be found buried in snow, and putrefaction present, death did not in all probability take place from cold, provided that the cold has been severe and continuous. Death from cold is generally accidental, except in newly-born children, when it may be either accidental or homicidal, according to circumstances.

When freezing of the body has taken place prior to the onset of *rigor mortis*, the latter comes on after the body thaws. This, combined with the other *post-mortem* signs given above, affords evidence of the strong probability that death had resulted from exposure to cold. In view of the red colour of the skin being similar to that caused by poisoning with CO, a spectroscopic examination of the blood should be made.

DEATH BY LIGHTNING.

Death is not always immediate. Sometimes the clothes have been torn off the body with scarcely any personal injury. *Metallic articles, especially steel, worn or carried about the person become magnetic.* The lesions which may be met with after lightning-stroke are varied, and may comprise wounds of almost any description; simple, compound, or comminuted fractures of bones; burns in the form of streaks, patches, lines, or arborescent markings; ecchymoses; singeing of the hair; impressions of metallic articles on the skin. Apart from the lesions noted above, the following symptoms may be present: deafness, blindness, paralysis, loss of memory, delirium, and convulsions. Not infrequently those killed by lightning are found in the same position that they occupied during life. The question may arise as to whether the deceased died by lightning or violence. The presence of a storm at the time when death is stated to have occurred, and other attendant circumstances, will in most cases point to the true cause of death. Metallic articles should be examined with regard to their electric state. Dr. Honiball tenders this caution: "Be not too sure that in every body found dead after a thunderstorm, and where no marks upon it are found, that death was due to lightning-stroke, for it may happen that death was due solely to cardiac syncope owing to sudden and startling fright." The statement by the celebrated John Hunter that *rigor mortis* is absent after death from lightning-stroke has been disproved, as also that the blood is abnormally fluid.

SUICIDE.

In medico-legal inquiries, it not infrequently becomes a question of the greatest importance to decide whether the death of a person found under peculiar circumstances was brought about by accident, suicide, or by the hand of a third party. Unfortunately, there are no infallible rules to be laid down on this subject; and Casper sagaciously remarks that "the exercise of a sound judgment, which is of far more value in medico-legal matters than all the subtleties of the ancient *medicina forensis*, must be our guide." But in order to attract the attention to some important matters in the inquiry, a few points worthy of notice will be placed in a tabular form:—

1. *Has the deceased made any oral statement, or left any written declaration of his intention to commit suicide?*

2. *Has there been any marked peculiarity in the conduct and manner of the deceased to point to any mental derangement?*

3. *Conditions under which the dead body was found.*

   (*a*) If in a room, was the door locked on the inside?
   (*b*) Position of the hand with regard to the weapon alleged to have been used.
   (*c*) If the weapon be firmly grasped in the hand, probability is in favour of suicide, as weapons placed in the hand after death to simulate suicide can be removed with ease, even when the *rigor mortis* is present.

4. *Nature and character of the wounds found on the body.*

   On suicides, incised and punctured wounds are generally found—seldom lacerated wounds, unless a jump from a height have been the means adopted to cause death.

5. *Evidence to be derived from a medico-legal examination of the body.*

   (*a*) Do the wounds correspond with the weapon alleged to have been used?
   (*b*) Examination of the stomach for poison.
   Why? Persons may have been poisoned first, and then cut about the body after death.
   (*c*) Direction and course of wound.
   (*d*) Were the wounds inflicted during life?

With regard to the legal relations of suicide, an attempt to commit suicide is not (within the meaning of sec. 15 of 24 and 25 Vict. c. 100) an attempt to commit murder, but it still remains a common law misdemeanour, triable at quarter sessions (R. *v.* Burgess). If two persons mutually agree to commit suicide by poison or other means, and one survive, the survivor is guilty of murder (R. *v.* Dyson, R. & R. 253). Also if any one, in attempting to commit suicide, cause the death of another, he himself recovering, he shall be guilty of manslaughter (R. *v.* Gathercole). In most of the English Insurance Offices, suicide is held to invalidate a policy, but in most cases where insanity is proved, the amount of the policy is paid (as in the case of Schwabe *v.* Clift). Suicides are deprived of the rites of Christian burial (4 Geo. IV. c. 52, sec. 1), and their bodies used to be buried where four roads met, with a stake driven through the coffin-lid; but a more recent Act now allows the bodies of suicides to be buried in churchyards, though without any religious ceremony.

CHAPTER XI.

OFFENCES AGAINST CHASTITY.

RAPE.

According to the Statute 24 and 25 Vict. c. 100, sec. 48, rape in England is defined as the "carnal knowledge of a woman against her will." In Scotland rape is held to be "the carnal knowledge of a woman forcibly and against her will, or of a girl below twelve years of age, whether by force or not" (Hume, i. 303). An Act passed in 1885 (48 and 49 Vict. c. 69) has materially affected the law on this subject as regards the age of females. To constitute the offence of rape, there must be *penetration*, but proof of the actual emission of seed is not now necessary. Before the Statute 9 Geo. IV. c. 31, sec. 18, it was also necessary to prove emission, which might be proved either positively by the evidence of the woman that she felt it, or it might be presumed from circumstances; as, for instance, that the defendant, after connection with the prosecutrix, arose from her voluntarily without being interrupted in the act. The slightest penetration of the male organ within the vulva will be sufficient, and the hymen need not be ruptured (R. *v.* Russen, 1 East P.C. 438, 439). The resistance of the woman must be to the utmost of her power. If, however, the woman yield through fear or duresse, it is still rape; but of course much will depend upon the previous character of the woman, and her conduct subsequent to the alleged outrage. The party ravished is a competent witness to prove this and every other part of the case; but the credibility of her testimony must be left to the jury. The defendant may produce evidence of the woman's notoriously bad character for want of chastity or common decency, or that she had before been connected with the prisoner himself; but

he cannot give evidence of any other particular facts to impeach her chastity (R. *v.* Hodgson, R. & R. 211). She may be asked if she has had connection with other men, but she need not answer (R. *v.* Cockcroft, 11 Cox, 410, per Willis J.). If she deny connection with the men named to her, they cannot be called to contradict her (R. *v.* Holmes, L.R. 1 C.C. R. 334).

A rape, according to Scotch law, may be committed on a common strumpet; and in England the law goes even further, and admits the possibility of rape on the concubine of the ravisher (1 Hale, 729), "although such circumstances should certainly operate strongly with the jury as to the probability of the fact that connection was had with a woman against her will." A husband may be guilty of rape on his wife if he hold her while another violates her, as in the case of the Earl of Castlehaven, tried in 1637. Carnal knowledge of a woman by fraud, which induces her to suppose it is her husband, now constitutes a rape by the 48 and 49 Vict. c. 69, which enacts that "whereas doubts have been entertained whether a man who induces a married woman to permit him to have connection with her by personating her husband, is or is not guilty of rape, it is hereby enacted and declared that every such offender shall be deemed to be guilty of rape." It has also been decided that if a man get into bed with a woman while she is asleep, and he know she is asleep, and he have connection with her while in that state, he is guilty of rape (R. *v.* Mayers, 12 Cox, 311, per Lush J.). The offence of rape is not triable at quarter sessions.

Upon an indictment for rape, there must be some evidence that the act was without the consent of the woman, even when she is an idiot. In such a case, where there was no appearance of force having been used to the woman, and the only evidence of the connection was the prisoner's own admission, coupled with the statement that it was done with her consent, the Court held that there was no evidence for the jury (R. *v.* Fletcher, L.R. 1 C.C. R. 39).

In another case, where the prisoner was caught in the act by the father of an idiot girl, the learned judge told the jury that if the prisoner had connection with the prosecutrix by force, and if she was in such an idiotic state that she did not know what the prisoner was doing, and if the prisoner was

aware of her being in that state, they might find him guilty of rape; but if, from animal instinct, she yielded to the prisoner without resistance, or if the prisoner, from her state and condition, had reason to believe she was consenting, they ought to acquit him. The jury found that he was guilty of an attempt at rape (R. *v.* Barratt, L.R. 2 C.C. 81).

Where the prosecutrix, an apparent idiot, proved that the prisoner had had connection with her, but it appeared from her examination that though she knew he was doing wrong, she made no resistance, and the prisoner, on being apprehended and charged with committing a rape upon the prosecutrix "against her will," said "Yes, I did, and I'm very sorry for it," it was held that there was evidence to go to the jury of a rape (R. *v.* Pressy, 10 Cox, 635).

In Scotland, in the case of Hugh M'Namara (H.C. July 24, 1848, Ark. 521), where the woman was only one degree removed from idiocy, it was laid down that "if she had shown any physical resistance, to however small an extent, the offence would be complete, in consequence of her inability to give a mental consent."

In future cases the above decisions will probably be set aside in the light of the present enactment.

In the case also of a quack doctor, who, under the pretext of performing a surgical operation on a young girl of nineteen years of age, had connection with her, she at the time resisting, but believing that she was undergoing an operation, it was held, on appeal, that he was guilty of the crime of rape, and the former conviction confirmed (R. *v.* Hattery, C.C.).

In England, and in Ireland, and also in Scotland, unlawfully and carnally knowing a girl under thirteen years of age constitutes a felony — the attempt in the former countries constitutes a misdemeanour; in Scotland, a "crime and offence." The child may be a witness if she understands the nature of an oath or understands the duty of speaking the truth, but her evidence must be corroborated by some other material evidence in support thereof, implicating the accused. The carnal knowledge of a girl above thirteen and under sixteen, or of any female idiot or imbecile woman or girl, under circumstances which do not amount to rape, but which prove that the offender knew at the time of the commission of the offence that the woman or girl was an idiot or imbecile, con-

stitutes a misdemeanour. Above sixteen, consent does away with the crime; and it shall be a sufficient defence for the accused to show that he had reasonable cause to believe that the girl was of or above the age of sixteen years. This defence does not apply to female idiots or imbeciles.

A boy under the age of fourteen was formerly in England presumed by law incapable of committing a rape (R. *v.* Groombridge, 7 C. & P. 582); but in Scotland there was no such provision, and a boy thirteen and a half years of age was committed for rape (Rob. Fulton, jun., Ayr, Sept. 20, 1841).

The recent Act before quoted provides that, instead of imprisonment, the offender, if *under* sixteen, may be whipped and sent to a reformatory school for not less than two or more than five years. Evidently age cannot now be pleaded as an incapability.

The crime of rape appears to be most frequently perpetrated against children, probably due to the popular idea that an attack of gonorrhœa may be cured by connection being had with a virgin or healthy female.

The following Table from Casper gives the result of his examination of one hundred and thirty-six cases of rape:—

From $2\frac{1}{2}$ (!) to 12 years old,	99
,, 12 ,, 14 ,,	20
,, 15 ,, 18 ,,	8
,, 19 ,, 25 ,,	7
47 ,,	1
68 ,,	1
	136

In examination of a case of alleged rape, several points of interest will have to be considered, which, for the sake of convenience, will be placed in a tabular form:—

1. *An examination of the parts of generation.*
   (*a*) Inflammatory redness and abrasion of the parts.
   (*b*) A muco-purulent secretion.
   (*c*) Hæmorrhage or dried blood about the genital organs.
   (*d*) Destruction of the hymen.
   (*e*) Dilatation of the vagina.
   (*f*) General signs of rape.
2. *An examination of the body and limbs of the female.*
3. *Examination of the linen worn by the female and the male for*
   (*a*) Marks of semen.
   (*b*) Marks of blood.
   (*c*) Marks of other discharges, gonorrhœa, etc.

1. An Examination of the Parts of Generation.

(*a*) More or less inflammatory *redness* and *abrasion* of the mucous membrane lining the parts, which is never absent in children, and may last for some weeks. "In adults, virgins up to the time of the commission of the crime, this appearance is either not found at all, or only faint traces of it. In those previously deflowered it is never observed." In the case of young children the genitals may be so injured as to cause death in a few hours. The parts may therefore present all varieties of injury, from slight bruising and redness to the most fearful lacerations.

Caution.—Inflammatory irritation due to catarrh *may* occur, and be apt to mislead.

(*b*) A *muco-purulent secretion*, from the mucous membrane lining the vagina, of a greenish-yellow colour, more or less viscid, and soiling the linen of the girl. This secretion, in colour and consistence, cannot be distinguished from that the result of gonorrhœa. The usual period of incubation of gonorrhœa is from three to eight days; among young girls, however, this period may be shortened. The incubatory stage of simple chancre is from three to five days (Diday); that of hard chancre somewhat longer, varying from fifteen to twenty days. Enlargement of the inguinal glands and the persistence of the discharge after the use of simple treatment will tend greatly to confirm the suspicion of venereal disease. The genital organs of the male may have to be examined as to the presence of gonorrhœa or syphilis. Syringing the urethra may remove for a time the gonorrhœal discharge; care must therefore be taken in forming an opinion.

Caution.—Unhealthy children, and those recovering from some debilitating diseases—fever, etc.,—may suffer from purulent discharges from the vagina. Small ulcers may also be present, and may be mistaken for syphilitic ulceration. Infantile leucorrhœa is not uncommon. (Percival's *Medical Ethics.*)

(*c*) *Hæmorrhage or Dried Blood about the Genital Organs.*—(1) Frequently absent in young children. (2) Always found in adults, virgins at the time the rape was committed, when the vessels of the hymen are ruptured.

(*d*) *Destruction of the Hymen.*—Most frequently, and especially in young girls, one or more *lacerations* of the hymen may be

seen. These lacerations must be looked for within five or six days of the alleged rape, as they soon heal up, and then no certain opinion can be given as to the date of their infliction. They may also be produced by any foreign body to substantiate a charge of rape.

(*e*) *Dilatation of the Vagina.*—This condition may be produced by the passage of hard bodies in order to substantiate a false charge of rape. Casper once examined a girl, only ten years of age, whose mother had gradually dilated her vagina with her fingers, in order to fit her for sexual intercourse with men.

(*f*) *General Signs of Rape.*—To the above are added certain general signs, as a *difficulty in walking*, attended with an involuntary separation of the thighs, common to both children and adults; *pain is also not infrequently present in passing water*, and when the *bowels are relieved*. In determining the truthfulness of the statements made as to an alleged rape, the character of the woman, and the obvious inconsistencies of her statements, must be taken into consideration. Moreover, if, in addition to the injuries found on the external genitals, spermatozoa be detected in the vagina, a presumption in favour of the injuries being due to sexual intercourse will be clearly made out, but the presence of spermatozoa in the vagina of a woman is no evidence of rape. Care, however, must be taken not to confound with spermatozoa an animalcule—*Trichomonas vagina*—described by M. Donné as being sometimes found in the vaginal mucus. The head of the animalcule is larger than that of a spermatozoon, and is surrounded by a row of cilia.

In the case of young children, the anxiety on the part of the parents of the child to push the charge, and the story of the child and that of the parent heard apart, may assist in guiding the opinion. The lesson-like way in which the child tells her story, even to the minutest details, is always suspicious. The proof of a previous defloration negatives the pretended loss of virginity at the time of the commission of the deed for which the accused is being tried. In most cases, it is best to let the patient tell her own tale, and then cross-examine. An injudicious question may put her on her guard.

2. Examination of the Limbs and Body of the Female for Bruises, etc.—Little value is to be placed on injuries said to be inflicted on the person of the female, the result of a struggle

as these may be produced by the woman on herself in order to substantiate her story. In children, for obvious reasons, they do not occur.

3. Examination of the Linen.—In all cases a careful examination of the body linen of both parties should be made. With regard to the position of the stains on the chemise of the woman, M. Devergie insists that the stains on the front of the chemise are seminal, those on the back are due to blood. This

Fig. 14.—Hymen of child of four years—annular type. The illustration also shows the prominence of the urinary portion of the genitals. (Glaister.)

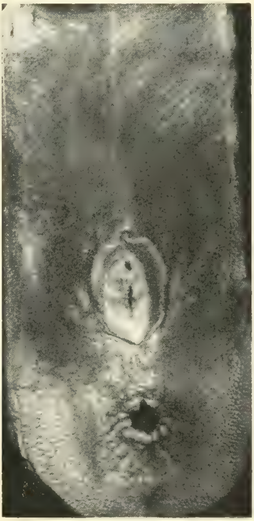

Fig. 15.—Virgin hymen, with central slit. (Glaister.)

distinction is too arbitrary to meet all the facts of these cases, for the position of the spots necessarily depends on the respective positions of the parties at the moment of ejaculation ; and moreover, the woman is more likely to wipe the parts with the front than the back of her chemise. Mistakes may arise from—

1. The garments being intentionally soiled with blood. This is not infrequently done in cases of false accusations.

2. The menstrual discharge may be readily mistaken for that due to violence, as the two kinds of blood cannot be distinguished.

3. The red juice of fruits and grease spots have been mistaken for marks of blood and seminal stains on linen.

The identification of blood-stains is not difficult when the stain occurs on pieces of white linen; but when, as it not infrequently happens, they have to be detected on the coarse, dirty, often stinking linen of the poor, the task becomes somewhat more difficult. The same may be said with regard to seminal spots. As a means of diagnosis in stains due to semen, the appearance and smell of the stains are of no assistance whatever. The microscope will alone give any trustworthy evidence as to the nature of the stain; and even here a caution must be added—for the fact is beyond doubt that the semen even of a healthy young man varies much, and is scarcely ever twice alike, so that the absence of spermatozoa is no proof that the spot is not seminal in its origin.

The following are the tests used for the detection of semen:—

1. *Characteristic Smell when the spot is moistened.*—This test is of no use, for the reasons before stated.

2. *Appearance when held to the Light.*—As uncertain as the preceding.

3. *Doubtful spots* upon *cotton* or *linen*—not upon *wool*, which usually contains sulphur—should be cut out and moistened with a few drops of oxide of lead, dissolved in liquor potassæ, and then dried at a temperature of 68° F. The stain in a few minutes becomes of a dirty yellow or sulphur-yellow colour. This change in colour proves that the mark *is not* a seminal stain. Semen does not contain albumen. This test only shows that the stain is not caused by albuminous compounds, which contain sulphur; but it does not follow therefore that the spot must be seminal, for marks made by gum, dextrine, and some other substances of a like nature are not changed in colour.

4. *The Microscope.*—This is by far the most reliable test, but care is required in its manipulation.

(*a*) The cloth must not be rubbed between the fingers, as the spermatozoa may be damaged by the operation.

(*b*) The suspicious spot on the linen should be carefully cut out and placed in a clean watch-glass or small porcelain vessel, and then moistened with a small quantity of distilled water. The cloth may be gently moved about in the water with a glass rod, and gentle pressure made so as to thoroughly wet the cloth, which, in most cases, will be accomplished in about a quarter of an hour. A single drop should now, by gentle pressure with the fingers, be squeezed on to a clean slide, and then placed under the microscope.

(*c*) Another method may be adopted. First determine the side of the cloth on which the stain is present, and cut out the stain, leaving a small strip of cloth attached to the main portion. Place the end of the strip in a little water in a watch-glass, so that the water by capillary attraction may permeate the entire stain. With a thin-bladed knife gently remove the moistened stain and place it on a microscopic slide, and examine as before.

Can a Rape be committed by one man on a healthy, vigorous woman?—The answer to the question will, to a great extent, depend on the relative strength of the conflicting parties. Every case of rape has to be judged on its own merits. In any case, the medical jurist has simply to state, from the examination of the parties, that sexual intercourse has taken place, leaving the jury to decide whether a rape or not has

FIG. 16.—Photo-micrograph of human spermatozoa, ×1000. (R. J. M. Buchanan.)

been perpetrated. A case is mentioned by Casper where a healthy, strong adult of twenty-five years old was violated by a single man.

Can a woman be violated during Sleep?—By this is intended natural healthy sleep, and not that induced by narcotics. In natural sleep, rape is scarcely possible in a virgin, especially if the hymen be found recently ruptured, though it *may* be possible in a woman accustomed to sexual intercourse.

Can a Woman become pregnant by an Act of Rape?—The answer to this question is most decidedly in the affirmative. It is not necessary for a woman to experience any sexual pleasure

during connection in order that she may conceive. A woman may become pregnant if fresh semen be injected into the vagina with a glass syringe.

Signs of Rape in the Dead.—In the case of a woman found dead, the question may arise as to her having been violated prior to death. The reply to the question is by no means easy. Severe injury to the genitals is a presumption in favour of rape, but cases are by no means rare in which men failing to accomplish coitus have injured the parts with their fingers. The presence of spermatozoa in the vaginal mucus is good evidence of a late coitus, but is no direct evidence of rape. Collateral evidence will in most cases decide the point.

Directions as to manner of making a Medico-Legal Examination in a Case of Alleged Rape.

1. Be careful to note everything, for it is in such cases as the one under discussion where apparently unimportant signs may become of the greatest moment.

2. Give the female no time for preparation, but make your visit, and at once proceed to an examination. The visit to be of any practical service should not be delayed beyond the third or fourth day after the alleged offence, "by which time the lacerations will have healed, the cicatrices disappeared, and the torn hymen be in such a state as to make it difficult to say whether it had been divided recently or at an earlier period." But remember that you *are not justified in using force*; and in this, as in cases of suspected pregnancy, if you examine a woman against her will you render yourself liable for an action for assault, and may have to pay heavily for your enthusiasm.

(*a*) Note time of visit.
(*b*) Note time of alleged offence. *Why?* May prove the accused party innocent by an *alibi*.
(*c*) Avoid leading questions.

3. Age, strength, and condition of the health of the complainant. Examine the wounds asserted to have been inflicted, and see if they correspond with the history given of their infliction.

4. Examine organs of generation.

(*a*) Any recent signs of violence—blood, abrasions, ulcerations, etc.
(*b*) Condition of hymen, and of the *carunculæ myrtiformes*.
(*c*) Was the woman menstruating at the time? Signs modified or obliterated by menstruation.

5. Preserve any spots on linen, etc., for future examination.

6. In case of death after violence—

(*a*) Examine mouth for foreign bodies, etc.
(*b*) Fractures or bruises on the body.

7. Examine spot where the crime is stated to have taken place.
8. Examine person of the accused.
   (*a*) Muscular development and strength.
   (*b*) Any abrasion about the penis, size of penis, rupture of the frænum, etc.
   (*c*) On linen, blood stains, seminal spots, etc.
   (*d*) Marks on his body, scratches, etc., as evidence of resistance.

N.B.—The lapse of a few days may be sufficient to remove all traces of the violence done to the parts; and in most cases days, weeks, and even months may elapse before an examination is made of the alleged victim.

PHYSICAL SIGNS OF RAPE IN ADULT AND IN CHILD

In the Adult.	In the Child.
1. If examined soon after the commission of the offence, the hymen of the adult virgin may be ruptured, and the fourchette may be lacerated, and the parts covered with blood.	1. There may not be sufficient penetration to rupture the hymen, consequently there will be no hæmorrhage. In other cases the external organs will be bruised, and in many cases severely lacerated, the laceration depending on the amount of penetration and force used.
2. Difficulty in walking, in passing water, and sometimes when the bowels are relieved. These signs in the adult pass off in a day or two.	2. Same as in the adult, but lasting for a longer time—from eight to fourteen days.
3. Injuries on the person abused, such as scratches and ecchymoses, may be present as the result of a struggle. These may be self-inflicted.	3. For obvious reasons these do not occur on children.

VIRGINITY.

There is no one sign which may be considered as an absolute test for virginity. The presence or absence of the hymen is of no probative value one way or the other. Its very existence has been denied by Paré, Buffon, and others. It may be absent as the result of disease, or as the result of a surgical operation to allow of the free discharge of the menstrual flow. Its presence is no bar to conception; and cases

are on record where it has been found necessary to incise it, to allow of the passage of the fœtus into the world. In fact, women who have been prostitutes for years have possessed to the last uninjured hymens. The changes in the breasts which proceed from impregnation do not occur where only defloration has taken place. The rugose condition of the vagina is only affected by the first birth, and not by sexual intercourse.

FIG. 17.—Deflorated hymen, after parturition, in adult woman. (Glaister.)

What has been said of the above signs as tests for virginity may be said of a host of others which from time to time have, with varying success, been advanced as aids to the diagnosis. Casper, however, considers "that where a forensic physician FINDS A HYMEN STILL PRESERVED, EVEN ITS EDGES NOT BEING TORN, AND ALONG WITH IT—in young persons—A VIRGIN CONDITION OF THE BREASTS AND EXTERNAL GENITALS, HE IS THEN JUSTIFIED IN GIVING A POSITIVE OPINION AS TO THE EXISTENCE OF VIRGINITY, and *vice versa*."

CHAPTER XII.

PREGNANCY.

It not infrequently happens that a medical man is called upon to make an examination of a woman for legal purposes, in order to decide—(*a*) The existence of an alleged pregnancy. (*b*) The possibility of a previous pregnancy. (*c*) As to the existence of concealed pregnancy.

The following are some of the reasons why pregnancy may be feigned :—

1. *By a married woman, to gratify the desire of her husband for issue.*
2. *To influence the jury in a case of breach of promise of marriage as to the assessment of the damages.*
3. *To extort money from a seducer or paramour.*
4. *To produce a spurious heir to property.*

The late insane attempt of Lady Gouch to produce an heir is a case in point.

5. *By a single or married woman, to stay the infliction of capital punishment.*

Pregnancy may be concealed—(*a*) In order to procure abortion. (*b*) In order to commit infanticide. (*c*) In the married and the unmarried, to avoid disgrace.

Besides the above, other important questions may arise with regard to this state :—

1. *Is pregnancy possible as the result of coïtus in a state of unconsciousness?*—There appears no reason for doubting the possibility of this occurrence.

2. *Can pregnancy occur before the appearance of the catamenia?*—That pregnancy may occur before menstruation is undoubted ; and it appears probable that the changes in the ovaries and uterus may go on at the regular monthly periods, and yet there may be no discharge of blood from the uterus, which, as pointed out by Bischoff, is only a symptomatic though usual occurrence. Hence, pregnancy is possible prior to menstruation.

3. *What is the earliest and latest age at which pregnancy is possible?* —In our climate (Britain), the earliest age at which pregnancy may occur is about the eleventh or twelfth year; but the youngest age at which this condition is reported to have occurred is *nine* years (Meyer). In hot climates—as in Bengal—mothers under twelve years of age are by no means rare. Cohabitation in marriage takes place much earlier in India than in Europe, but Chevers doubts if menstruation naturally occurs much sooner there than elsewhere, and Baboo Modusoodun Gupta believes that the catamenia appear sooner or later, according to the mode of living of the females, and the sexual excitement to which they may be subjected. Thomas mentions the case of a girl who menstruated regularly from the age of twenty-one months, and also of another at eight months. The limit to child-bearing appears to be between the fiftieth and fifty-second years; but even here considerable variation has been recorded, and women have been delivered of children at the age of sixty. Haller even reports one at seventy. As long as menstruation continues a woman may become pregnant; but even the cessation of this flow for some months is no bar to conception.

4. *Is it possible for a woman to become pregnant eight weeks after her last confinement?*—This is undoubtedly possible, but it is of rare occurrence. It is also probable that a woman may abort at the end of the time above mentioned. Husband knew a woman, since dead, who for several years bore a child every ten months.

At *common law*, in cases of disputed inheritance, the following may occur, and give rise to the necessity for medical evidence on the subject:—A woman who has just lost her husband may disappoint the expectant heirs to an estate by alleging that she is pregnant.

At *criminal law*, pregnancy may be used as a stay to the infliction of capital punishment.

In the first case, a jury of matrons is impannelled by a writ *de ventre inspiciendo*, to decide the existence of pregnancy, and if the fact be proved, to watch till such time as she be delivered.

In the second case, in England, the pregnancy must be proved, and also whether she be *quick with child*. In Scotland the pregnancy must be proved, but without reference to *quickening*, and the jury of matrons is unknown in that country. In the same country, if it can be shown that a woman is pregnant, and that her life or that of the child is endangered by her imprisonment, she may be admitted to bail till after delivery. A pregnant female also cannot be compelled to appear and give evidence, if on competent authority it be shown that her delivery will probably take place at the time fixed for the trial.

Signs of Pregnancy.

The diagnosis of early pregnancy in ordinary cases is by no means easy, especially between the third and fourth months of gestation; but to the medical jurist it is still more difficult, as he has to deal with cases where he can scarcely expect much candour. No opinion should, however, be given without taking into consideration the collective value of the signs, as no one sign will afford sufficient data on which to base an opinion. The signs furnished by auscultation are the most reliable, but the position of the fœtus may render the sounds of the fœtal heart and placental souffle difficult to detect.

The following may be taken as among the most important signs of pregnancy, given in the usual order of their occurrence:—

UNCERTAIN OR ACCESSORY SIGNS.

1. Cessation of menstruation	First month.
2. Morning sickness	Second month.
3. Salivation	Variable.
4. Mammary sympathies	Third month.
5. Enlargement of the abdomen	Fourth month.
6. Quickening	Fourth month.
7. Kiesteine	Variable.
8. Jacquemier's Test	Third month.

CERTAIN OR ESSENTIAL SIGNS.

1. Ballotement	Fourth month.
2. Uterine souffle	Second month.
3. Pulsation of the fœtal heart	Fourth month.

UNCERTAIN SIGNS

1. *Cessation of Menstruation.*—The non-appearance of the catamenia, though a most valuable sign, is by no means a conclusive one, as menstruation may be arrested by diseases of various kinds; while, on the other hand, there are many well-recorded cases of women who have menstruated regularly during the whole period of their pregnancy. There have been also cases in which the menses only occurred during pregnancy; and in a few still more curious cases, women who have never menstruated have been known to have borne several children. In cases of concealed pregnancy, the woman may smear her linen with blood to imitate the menstrual flow,

2. *Morning Sickness.*—Nausea, often ending in vomiting, generally occurs soon after rising in the morning, and may commence almost immediately, but more frequently not till the expiration of the fifth or sixth week after conception. It is not a reliable sign, and is often very irregular in its occurrence. When present, it varies in degree, from a feeling of nausea to the most violent vomiting, very distressing to the patient.

3. *Salivation.*—The excessive secretion of the salivary glands, due to the irritation caused by pregnancy, was first mentioned by Hippocrates as a sign of this condition. "It is to be distinguished from ptyalism induced by mercury, by the absence of sponginess and soreness of the gums, and of the peculiar fœtor, and by the presence of pregnancy." It is oftener absent than present.

4. *Mammary Sympathies.*—As the breasts may enlarge from various causes—such, for instance, as the distension of the uterus from hydatids, or, as is the case with some women at each menstrual period, when the catamenia are suspended, or after they have ceased—this is by no means a sign on which much reliance should be placed. The change in the colour of the nipple and areola, more apparent in women of dark complexions, is more to be relied on as a diagnostic sign of pregnancy. The first observable alteration, which occurs about two months after conception, is "a soft and moist state of the integument, which appears raised, and in a state of turgescence, giving one the idea that, if touched by the point of the finger, it would be found emphysematous. This state appears, however, to be caused by infiltration of the subjacent cellular tissue, which, together with its altered colour, gives us the idea of a part in which there is going forward a greater degree of vital action than is in operation around it; and we not infrequently find that the little glandular follicles, or tubercles as they are called by Morgagni, are bedewed with a secretion sufficient to damp and colour the woman's dress." During the progress of the next two months, the changes in the areola are in general perfected, or nearly so, and then it presents the following characteristics:—"A circle round the nipple, whose colour varies in intensity according to the particular complexion of the individual, being usually much darker in persons with black hair, dark eyes, and sallow skin, than in those of fair hair, light-coloured eyes, and delicate

complexion. The extent of the circle varies in diameter from an inch to an inch and a half, and increases in most persons as pregnancy advances, as does also the depth of colour. In the centre of the coloured circle, the nipple is observed partaking of the altered colour of the part, and appearing turgid and prominent, while the surface of the areola, especially that part which lies more immediately around the base of the nipple, is studded over and rendered unequal by the prominence of the glandicular follicles, which, varying in number from twelve to twenty, project from the sixteenth to the eighth of an inch; and, lastly, the integument covering the part appears turgescent, softer, and more moist than that which surrounds it; while on both there are to be observed at this period, especially in women with dark hair and eyes, numerous round spots or small mottled patches of a whitish colour, scattered over the outer part of the areola, and for about an inch or more all around, presenting an appearance as if the colour had been discharged by a shower of drops falling on the part." The value of the above changes in the nipple and areola as a diagnostic sign of pregnancy is greatly lessened by a previous pregnancy. It should also be remembered that milk may occur in the breasts of women who are not pregnant.

5. *Enlargement of the Abdomen.*—For the first four months of pregnancy the entire uterus is contained in the cavity of the pelvis; it then gradually rises, so that at about the fifth month it is midway between the pubes and umbilicus, which latter it reaches at the end of the sixth month; during the seventh month it may be felt half-way between the umbilicus and ensiform cartilage; at the end of the eighth month it is level with the cartilage, now quite filling the abdomen. Still increasing in size during the ninth month, it does not ascend higher, the abdominal walls yielding to its increased weight, allowing it to fall somewhat forward. A caution is necessary with regard to this sign. The abdomen may enlarge from causes other than pregnancy. Pregnancy and ascites, or ovarian dropsy, may coexist in the same patient, and the diagnosis be rendered anything but easy. The enlargement of the abdomen may lead to unfounded suspicions detrimental to the happiness and health of the unfortunate object of them. The cervix uteri in the latter months of pregnancy presents the following characteristics:—At the sixth month it loses one-

fourth of its length; at the seventh it is only half of its original length; at the eighth it loses another quarter; and at the ninth the neck is entirely obliterated. This shortening is more apparent than real, and its occurrence is denied by the late Dr. J. M. Duncan, except during the last few days of pregnancy.

6. *Quickening.*—The period at which quickening occurs varies from the fourth to the fifth month; and the term is understood to imply the first perception of the movements of the fœtus experienced by the mother. Nervous women, anxious to have children, sometimes complain of sensations which they ascribe to quickening, pregnancy being absent. Pregnancy may occur without quickening.

7. *Kiesteine.*—This is no test of pregnancy, as it may be found in women not pregnant.

8. *Jacquemier's Test.*—A violet or port-wine colour of the vagina and inner surface of the vulva, due to venous congestion of the parts from pressure of the gravid uterus.

A flattening of the upper wall of the vagina, produced by the enlargement and anteversion of the uterus, which, forcing the os towards the sacrum, makes the anterior wall of the vagina tense, has been added by Dr. Barnes as a sign of pregnancy.

This ends the account of those signs of pregnancy which are least to be relied on in forming a diagnosis, and which are only useful when taken in the aggregate.

Certain Signs.

1. *Ballottement.*—This test of pregnancy is applied by causing the patient to stand upright; the finger of the right hand is then passed into the vagina and placed on the mouth of the womb, the other hand being placed lightly over the abdomen in order to steady the uterine tumour. If the finger be now jerked upwards against the head of the child, it will be felt to float upwards in the liquor amnii, and then by its own weight gradually to return to its former position. Tumours in the uterus, attached to its walls by a pedicle, may give the same sensation. Scanty supply of liquor amnii, or mal-position of the child, may sometimes prevent the adoption of the test.

2. *Uterine Souffle.*—Under this head are included the

placental bruit, and the pulsations of the umbilical cord. Both these sounds require a most skilled auscultator to detect them. The uterine murmur, or *bruit placentaire*, is heard best at the lower and lateral portions of the uterus, just above Poupart's ligament. It is isochronous with the pulse of the mother, and is heard most distinctly about the fourth or fifth month of utero-gestation; in some cases, however, it may be heard as early as the tenth week. The sound is intermittent, and varies in character, being sometimes hissing, whirring, or cooing, at others rasping.

3. *Pulsation of the Fœtal Heart.*—The sounds of the fœtal heart were first noticed by Mayar in 1818, and those of the placenta, or *placental souffle*, by Kergaradec in 1822. The sound of the fœtal heart is composed of a rapid succession of short, regular double pulsations, differing from that of the adult heart in rhythm and frequency. It can be heard more or less over the whole of the abdomen about the middle of the fourth month, and is not unlike the muffled ticking of a watch. In frequency it varies from 100 to 140. The auscultator should be careful not to hang his head down, or he may be apt to mistake the throbbing of his own arteries for sounds communicated from the patient.

The medical jurist must be prepared for the following among many other questions which will come under his notice:—"An unmarried woman with abdominal enlargement has been wrongfully accused of being pregnant. Enumerate the various conditions which produce abdominal enlargement, and give the diagnosis of them."[1]

Pregnancy may be simulated by ascites, by fibrous tumours of the uterus, by ovarian dropsy, and by enlargement of the uterus from retention of the catamenia due to an imperforate hymen, etc. The breasts may also become affected by uterine tumours.

Diagnosis of Pregnancy.

1. *Pseudo-Pregnancy.*—In the examination of cases of alleged pregnancy, the medical jurist should bear in mind the possibility of enlargement of the uterus and abdomen from the presence of tumours. The probable occurrence of *pseudo-*

[1] See Husband's *Collection of Medical and Surgical Questions.* Second edition. London.

pregnancy should also be considered. Tumours and pseudo-pregnancy may occur in the married and unmarried; and as the latter is not unfrequently accompanied with many of the signs and symptoms of pregnancy, an early diagnosis is of the utmost importance.

The diagnosis will consist in—

(*a*) A careful examination of all the symptoms present, when, in most cases, a break in their order of sequence may be observed, or certain signs may be added which do not occur in true pregnancy.

(*b*) Presence or absence of the hymen.

(*c*) If the patient be placed well under the influence of chloroform, the tumour, if the result of pseudo-pregnancy, will subside, gradually returning as the effects of the anæsthetic pass off. Whilst the patient is under the influence of the anæsthetic, the hand may be pressed on the abdomen at each expiration, and there retained, the pressure being continued during the inspirations.

It is stated that Liston once cut into a woman for a phantom tumour, and declared that he had never seen more healthy bowels in his life.

2. *Dropsy.*—Use of the stethoscope; examination of the breasts for milk, and the urine for albumen.

3. *Fibrous Tumours.*—Absence of fœtal movements and other signs of pregnancy.

4. *Ovarian Dropsy.*—Tumour on one side of the abdomen; breasts unaffected, and auscultation giving negative results.

5. *Retention of the Catamenia.*—On examination, the hymen found perfect and bulging. This condition cured by a crucial incision.

DELIVERY.

This subject is best discussed under three heads:—(1) Signs of Recent Delivery in the Living. (2) Signs of Recent Delivery in the Dead. (3) Signs of Previous Delivery.

1. Signs of Recent Delivery in the Living.

(*a*) Transitory Signs; (*b*) Persistent Signs of Delivery.

(*a*) Transitory Signs of Delivery.

1. *General Indisposition.*—The face is pale or flushed; the eyes sunken, and surrounded by a dark areola; there is considerable debility, and a tendency to faint; the skin is warm and moist, and the pulse quick. It must be borne in mind

that a woman who is anxious to conceal her recent delivery may, by an effort of the will, to a great extent hide her real condition.

2. *The Breasts.*—The breasts feel firm and "knotty," and on pressure yield a small quantity of *colostrum* or milk, which may be distinguished by the aid of a microscope.

3. *The Abdomen.*—The skin of the belly shows signs of recent distension; it is relaxed, and more or less thrown into folds, the lower part marked by irregular broken streaks of a pinkish tint, becoming white and silvery as time goes on.

4. *The Lochia, or the "Cleansings."*—These consist in a discharge from the uterus, which, for the first three or four days after delivery, is more or less bloody. During the succeeding four or five days it acquires a dirty-greenish colour—"green waters," with a peculiar sour, rancid odour. In a few days this is succeeded by a yellowish, milky, mucous discharge, which may continue for four or five weeks.

5. *External Parts of Generation.*—The labia and vagina bear distinct marks of injury and distension.

6. *The Uterus.*—The uterus is enlarged, and may be felt by the hand for two or three days after delivery, as a round ball, just above the pubis. The orifice of the uterus, if examined a few hours after delivery, appears as a continuation of the vagina. This condition completely disappears in about a week after delivery.

7. *After-pains.*—These are of no use from a diagnostic point of view, as we have no means of testing their presence or absence.

(*b*) Persistent Signs of Delivery.

1. *Entire obliteration of the hymen.*—This is no proof of actual delivery.

2. *Destruction of the fourchette.*

3. *The vagina dilated, and free from rugæ.*

4. *Dark colour of the areola round the nipples.*—This varies among women; and cases are known where there was no areola either during pregnancy or after delivery.

5. *Skin of Abdomen.*—Due to the great distension of the abdomen, the skin appears streaked with silvery lines varying in breadth. These markings in some cases may be scarcely perceptible, especially if the female has worn a tight abdominal

belt during her pregnancy. The same appearance may be produced by dropsy, or the prolonged distension of the abdominal walls, the result of other causes. Husband once saw these markings most characteristically present in a young man just recovered from an attack of ascites. His sex precluded any error in diagnosis as to the cause of the marks. Attention to the other signs present will assist the diagnosis. After the lapse of seven to ten days the recent delivery of a woman cannot be certainly proved by an examination of the living woman, especially if it be known that she had previously borne children. In primipara the pink-coloured streaks on the abdomen, and the transverse condition of the os uteri, may strongly point to recent delivery.

2. Signs of Recent Delivery in the Dead.

Should the woman die immediately after delivery, the external parts will present the same appearance as just described in the living. On opening the abdomen, the uterus will be found fat and flabby, between nine and twelve inches long, and with the os uteri wide open. The cavity of the uterus may contain large bloody coagula, and its inner surface lined by the decidua. The attachment of the placenta is easily detected by its dark colour, and by the semi-lunar openings of the arteries and veins on the surface of the uterus.

Of course all the appearances just described will be greatly modified by the time that has elapsed between delivery and death.

Delivery after Death.—The fœtus has been known to have been expelled from the uterus by the force of the gases generated by putrefaction. Dr. Aveling, in a paper published in the *Obstetric Transactions*, 1873, arrives at the conclusion that *post-mortem* delivery is possible even where no symptoms of parturition were noticed before death. He also thinks that the child may live *in utero* for some hours after the death of the mother.

TABLE SHOWING THE SIZE OF THE UTERUS AT DIFFERENT PERIODS AFTER DELIVERY.

Two to Three Days.—About 7 inches long and 4 inches wide.
Seven Days.—Between 5 and 6 inches long and 2 inches wide.

Fourteen Days.—From 4 to 5 inches long and $1\frac{1}{2}$ inches wide.
End of Second Month.—Normal size. $2\frac{1}{2}$ inches long and about 2 inches broad at the fundus.

TABLE GIVING WEIGHT OF THE UTERUS AFTER DELIVERY.

Immediately after Delivery	. .	22 to 24 ounces.
Within a Week .	. . . .	18 to 21 ,,
End of Second Week	. . .	10 to 11 ,,
End of Third Week .	. . .	5 to 7 ,,
End of Second Month	. normal,	9 to 10 drachms.

(HESCHL.)

3. Signs of a Previous Delivery.

1. *Marks on the abdomen*, consisting in shining silvery lines, due to the distension of the skin. These may result from distension other than that the result of pregnancy—tumours, dropsy, etc.

2. *Marks on the breasts*, similar to those appearing on the abdomen. These, in conjunction with the above, are important.

3. *Peculiar jagged condition of the os uteri*, felt by the finger. This condition may be the result of disease.

4. *Marks of rupture of the fourchette or perinæum.*

5. *Dark colour of the areola round the nipples.*

6. *Negative evidence*, from absence of any of the above.

Can a Woman be delivered unconsciously?—This question may arise in cases of infanticide. Setting aside cases of epilepsy (in a fit of which disease Husband once attended a woman who was confined during the fit without being aware that she had been delivered), cases of apoplexy, coma, and narcosis from chloroform, opium, etc., it may be stated that delivery is possible during profound sleep. Husband once attended a woman who informed him that "she always had her pains during her sleep," and only woke up just as the head came into the world. When it is borne in mind how easily some women pass through labour, it is quite possible that, after a busy day, sleep may be so profound as not to be disturbed by the pains of labour. In primipara the occurrence is more problematical. Women have often declared that they have been unconsciously delivered whilst at stool. This is also probable, but the circumstances of the case must be severely sifted.

CHAPTER XIII.

FŒTICIDE, OR CRIMINAL ABORTION.

[" *Every woman, being with child, who, with intent to procure her own miscarriage, shall unlawfully administer to herself any poison or other noxious thing, or shall unlawfully use any instrument, or other means whatsoever, with the like intent: and whosoever, with intent to procure the miscarriage of any woman, whether she be or be not with child, shall unlawfully administer to her, or cause to be taken by her, any poison or other noxious thing, or shall unlawfully use any instrument, or other means whatsoever, with the like intent, shall be guilty of felony, and being convicted thereof shall be liable, at the discretion of the Court, to be kept in penal servitude for life, or for any term not less than five years, or to be imprisoned for any term not exceeding two years, with or without hard labour, and with or without solitary confinement.*"—STATUTE 24 AND 25 VICT. C. 100, SEC. 58.]

THE 59th section of the same Statute also takes into consideration the unlawfully supplying or procuring any poison, or other noxious thing, or instrument, or thing whatsoever for a woman, for the purpose of inducing abortion. The person so doing shall be guilty of a misdemeanour, and be kept in penal servitude for a term of five years, or be imprisoned for any term not exceeding two years, with or without hard labour.

It will be seen from the passages above quoted that there is no distinction between a woman *quick* or not *quick* with child. "The offence is to procure the miscarriage of *any woman, whether she be or be not with child*" (R. *v.* Goodhall, 1 Din. 187 ; 2 C. & K. 293). But although the law does not regard "quickening" in cases of abortion, yet the fact of having "quickened" may be pleaded as a bar to immediate capital punishment.

It has been decided in Scotland that drugging or operating to procure abortion is criminal, though unsuccessful, but it is

not certain whether the woman alone can be charged with taking drugs to procure abortion. Both in England and in Scotland, to make the procuring of abortion criminal, "there must be felonious intent," for it may be necessary to cause abortion. It must be borne in mind that the law allows no discretionary power on the part of medical practitioners who, to save the life of the mother, may deem it advisable to induce premature delivery. This being the case, no medical man

Fig. 18.—Abortion at fourth week. (Glaister.)

Fig. 19.—Abortion between sixth and eighth week. (Glaister.)

Fig. 20.—Abortion at tenth week. (Glaister.)

should attempt to induce premature labour without the consent of the relatives of the woman, and the sanction of a medical colleague after consultation. This precaution is the more necessary as several medical men have of late years been prosecuted, an event which would not have taken place had the precaution above suggested been observed. A medical man should also be very careful never to give any medicine "to bring on the courses" if he has the slightest suspicion of pregnancy, even as a "placebo" to satisfy an importunate

patient, for should abortion be otherwise procured, his really harmless medicine may be accused with the result, and a grave suspicion be raised against him, to say the least.

The term *abortion* is understood in *medicine* to mean the expulsion of the contents of the fœcundated uterus before the sixth month of pregnancy, that is, before the child is considered viable. After this period it is said to be a premature labour.

In law, however, no distinction is made, and the expulsion of the contents of the uterus at *any* period before the full time of pregnancy is considered an *abortion*; in popular language, a *miscarriage*.

Abortion, when not produced by criminal means, generally occurs at or a little before the *third month* of utero-gestation, and then usually in first pregnancies, or during the latter part of the period of child-bearing. It is also more frequent among the rich than among the poor. Of the two thousand cases of pregnant women examined by Dr. Whitehead of Manchester, the sum of whose pregnancies was 8681, or 4·38 for each, rather less than 1 in 7 had aborted.

When abortion is criminally induced, it generally takes place between the *fourth and fifth months*, that is, about the time the woman becomes certain of her condition.

The Causes of Abortion are—

1. NATURAL OR ACCIDENTAL.—(*a*) Maternal—belonging to the mother; (*b*) Fœtal—belonging to the ovum.
2. VIOLENT.—(*a*) Mechanical; (*b*) Medicinal.

1. Natural or Accidental.

(*a*) **Maternal.**—Among the maternal causes may be mentioned excessive lactation; any irritation of the rectum or bladder; loss of blood, which, by increasing the amount of carbonic acid in the blood, acts as an excitant to the spinal cord; excessive irritability and excitability of the uterus, etc. Certain states of the system conduce to abortion—albuminuria, syphilis, certain fevers, scarlet fever, smallpox, etc. Abortion may become habitual in some women. Great joy or sudden sorrow have not infrequently been the cause of abortion. The tendency to abortion is greatest at the menstrual periods, that is, at the time when, had not the woman become pregnant, menstruation

would have taken place. Slight causes acting at these times are very liable to produce abortion.

(*b*) **Fœtal.**—The death of the ovum, or a diseased condition of its uterine coverings, or of the placenta, probably of an inflammatory nature.

2. Violent.

(*a*) **Mechanical.**—Under this head may be mentioned the passage of certain instruments into the cavity of the womb, and the rupture by violence of the membranes which surround the fœtus. A medical man practising in Yorkshire informed Husband that so great was the dread of large families, that he knew of several ladies who, if they went a day over their monthly period, passed a catheter into the uterus, with the desired result. "It was wonderful," he added, "how clever they were." In India a twig of the *Euphorbium nivulia*, anointed with assafœtida, is used for the same purpose. "The fœtus is never delivered alive, but there is said to be no great danger to the woman" (Chevers). In some cases it is by no means easy to procure abortion, and women have been known to undergo a considerable amount of violence without abortion taking place. In some women, however, on the other hand, the slightest violence—such, for instance, as slipping from a step or low chair—will cause them to abort.

(*b*) **Medicinal.**—Certain drugs, among which may be mentioned ergot, savin, pennyroyal, and a host of others, have been used for the induction of abortion.[1] In India unripe pineapple has a great reputation as an abortive (*Medical Jurisprudence for India*, Chevers). It is scarcely necessary to mention each drug individually, but it must be remembered "that there is *not one single internal medicament* of which it can be consistently with experience asserted that, even when an abortion has followed its use, it must have produced this abortion, and that cause and effect are in such a case in direct and necessary connection." All the so-called *abortives* are most uncertain in their action, and their use is attended with considerable risk to the woman. Be this as it may, they are more frequently used to induce abortion than mechanical procedure, from the fact that the latter requires some amount of anatomical knowledge and manipulative skill, which in Yorkshire, if not elsewhere, appears to have been acquired.

A medical man may be required to—(1) Examine into the nature and characters of the substances expelled from the womb; (2) Examine the woman stated to have aborted.

1. Examination of the Substances expelled from the Womb.—The substances expelled from the womb often become the subject of judicial inquiry, and the medical man may be required to give his opinion as to their probable nature.

Dr. Gallard has called attention to the following:—

1. During the last six months of pregnancy, abortion, even when it occurs spontaneously, goes through the two stages as at full time, *i.e.* the expulsion of the products of conception is, as a rule, preceded by rupture of the membranes, followed after a time by the expulsion of the placenta.

2. In the first three months this order of things is absent, for it is the rule to see the fœtus expelled entire *en bloc* without rupture of the membranes.

3. If, then, we find during the first three months of pregnancy the products of an abortion in which the membranes have been ruptured and the embryo expelled alone, we must look for a pathological cause for this infraction of a general rule; and if no disease of the embryo or of the mother is found, we are justified in attributing the abortion to mechanical means used directly against the products of conception. Charpentier has shown that this rupture of the membranes is not an absolute proof of criminal abortion; but in eighteen cases of spontaneous abortion M. Leblond only found rupture of the membranes in one, and in this the membranes presented an abnormal friability.

The questions may be asked—(1) Is it a fœtus?—(2) Is it a mole? If so, is a mole also a fœtus?—(3) Is it merely the coats of the uterus, and unconnected with pregnancy?

1. *Is it a Fœtus?*—The development of the fœtus is given on pp. 191 *et seq.*

2. *Is it a Mole?*—This question gives rise to another: Is a mole a fœtus? To this the answer must be in the affirmative. Moles, being the diseased appendages of the fœtus, vary in character, and have been described by obstetrical writers under the following heads:—(*a*) Hydatiginous; (*b*) Carneous; (*c*) Fatty Moles.

(*a*) *Hydatiginous Moles* are a result of a diseased condition of the villi of the chorion. The villi become dropsical, and hang in masses like a bunch of grapes.

(*b*) *Carneous Moles.*—These are the result of hæmorrhage into the chorion. The blood becomes organised, and a fleshy mass is formed, to which in some cases a withered fœtus is attached.

(*c*) *Fatty Moles.*—Death of the fœtus and fatty degeneration of the

placenta, or fatty degeneration of the placenta and death of the fœtus, produces this variety of mole. A withered fœtus with a mass of fatty placenta are expelled.

3. *Is it merely the Coats of the Uterus, and unconnected with Pregnancy?*—Fleshy masses may be expelled from the womb, which may not be the result of sexual intercourse. The description just given of true moles will, it is hoped, assist in forming a correct diagnosis. Considerable care will be required, for the honour of the woman accused depends upon the opinion given as to the nature of the substances submitted for examination. It must also not be forgotten that moles may be retained for many months in the uterus, and be then expelled. The knowledge of this fact may rebut an accusation of infidelity against a wife. Polypi may be discharged from the womb; the presence of a pedicle will point to their true character. All substances expelled from the uterus should be carefully washed in water, and all clots removed. The examination of the woman may also help in the formation of the diagnosis. The absence of the signs of defloration or of recent delivery will be in her favour.

2. **Examination of the Woman stated to have aborted.**—This subject may be divided under two heads—(1) Has the woman been recently delivered? (2) What were the means used to procure the abortion?

It is by no means easy to answer the question whether an alleged abortion has really taken place or not. The signs of recent delivery are in most cases absent, for the woman can better hide her condition during the earlier than during the later months of utero-gestation; consequently suspicion may not have been aroused against her for some weeks or months after the event. The history of the case, with other attendant circumstances—milk in the breasts, change in the colour of the areola round the nipples, severe flooding, absence of the hymen, injuries to the os uteri, transverse condition of the os uteri in contradistinction to its circular form after delivery, etc.,—will, in most cases, assist in forming a correct diagnosis; but it must be again repeated that few of the signs applicable to delivery at the full time are here available.

In all doubtful cases—

1. Examine into the general and present state of the health of the woman.

2. Find out if there are any reasons which would occasion a pretext to use drugs which are not usually given to women during pregnancy.

3. Learn if menstruation is regular and easy, or if the woman is in the habitual use of emmenagogues, for, if so accustomed, she may have used them ignorant of pregnancy.

4. If a woman ascribes her abortion to a fall, to an accident, or to violence used against her, carefully examine into the nature of these.

5. Examine into the general causes of abortion, and also inspect the expelled substances.

Where death is supposed to have followed the use of abortives, the alimentary canal must be examined for the signs of the action of irritants, or the presence of disease in the internal organs ; but when death has resulted from an attempt to procure abortion by instrumental means, the neck of the womb is most frequently found covered by a number of small more or less irregular wounds, which may penetrate into the womb or lose themselves in the walls of the organ. Their course is indicated by infiltration, or a small extravasation of coagulated blood, the exact condition of which must, if possible, be ascertained, so as to decide when the wound was inflicted.

The examiner must not forget that the wounds may extend to the fundus of the uterus, and in this case the autopsy shows that a blunt instrument, as a catheter or uterine sound, introduced through the os uteri into the retroverted uterus, glides by its own weight into the rent. The seat of the tear leads one to think that pregnancy was not far advanced when the attempt was made, and in fact the accident most frequently occurs in cases of suspected pregnancy. It must be remembered that the uterus is often punctured by the injudicious use of the uterine sound, but without any immediate dangerous symptoms. Wounds in the walls of the vagina indicate the use of instruments by an inexperienced hand ; in the fundus of the uterus, to one at least accustomed to the introduction of instruments. Spontaneous rupture of the uterus is impossible during the early periods of pregnancy, just when the attempts at abortion are usually made. Rupture due to external violence is, as a rule, accompanied with outward signs of the violence used.

In all cases a careful examination of the structure of the uterus should be made. An examination of the ovaries for *false* or *true corpora lutea* should be made. The opinions on the character and differences of these bodies are so discordant

as to destroy all confidence in their value as proof of conception or the reverse.

Taylor says: "The discovery of the *ovum* in the uterus *in process of development* could alone, in the present state of our knowledge, warrant an affirmative opinion on this point in a Court of Law, and this I believe to be the safest view at present of this much-contested question. On the other hand, the absence of a corpus luteum from the ovary would not in all cases warrant an opinion that conception had not taken place."

Recapitulation.

In Medicine, Abortion occurs before the sixth month of pregnancy—premature labour after that period.

In Law, Abortion may take place any time before the full period of utero-gestation.

Abortion may be due to—

1. *Natural or Unavoidable Causes.*
   (*a*) Maternal. (*b*) Fœtal.
2. *Violence, with Criminal Intent.*
   (*a*) Mechanical. (*b*) Medicinal.

CHAPTER XIV.

INFANTICIDE.

According to the present state of English law, infanticide—murder of a *new-born* child—is not regarded as a specific crime, but is treated and tried by those rules of evidence which are applicable in cases of felonious homicide, but with this difference, that the law requires proof that the child was born alive. An old Statute (21 J. I. c. 27) made the concealment of the birth of a bastard child conclusive evidence of murder. As far as the legal estimation of the crime is concerned, it matters not whether the child was killed immediately on its entrance into the world, or within a few days afterwards. A fœtus not bigger than a man's finger, but having the shape of a child, is a child within the Statute (R. *v.* Colmer, 9 Cox, 506 ; R. *v.* Hewitt, 4 F. & F. 1101). An English judge, at a late trial, stated that if the jury were of opinion that the prisoner had strangled her child before wholly born, she must be acquitted of murder. The law also, on the score of humanity, presumes that every child is born dead until direct evidence to the contrary, from medical or other sources, is given. The onus of the proof of live birth, therefore, devolves on the prosecution. It may also be difficult to decide as to the maternity, and the woman accused will have to be examined as to the possibility of her recent delivery.

Here let me repeat the advice given on page 156 as to the examination of women. Your duty is to request the woman to allow of the necessary examination, giving her the warning which every magistrate or coroner is bound to give to any person charged with a crime, before requiring an answer to a question which may be used in evidence against her at the subsequent trial. The innocent and the guilty may alike object

to an examination, but the presumption is against the party declining, if several have voluntarily submitted. A young lady committed suicide rather than submit to an examination by two medical men under an order from the coroner. The medical men were guilty of a grave indiscretion, and both they and the coroner were acting *ultra vires* in attempting to force a woman to obtain evidence against herself (Taylor, vol. ii. p. 431). The decision as to recent delivery will, to a great extent, rest on the condition of the mother, and the apparent age of the child found dead. The discovery of the body of the child is not necessary to conviction, but the medical evidence as to the signs of respiration, of course, depends on the body being found and examined. In most cases of alleged infanticide tried in England, juries appear more inclined to fall back on the minor offence—*concealment of birth*—than to convict of the capital offence; and this appears to be the only alternative if the body cannot be found, for, as we have just said, in law every child is held to be born dead. It must of course be shown that the woman has been recently delivered. In case of failure to prove the murder of the child, the Act (24 and 25 Vict. c. 100, sec. 60) enacts that "if any woman shall be delivered of a child, every person who shall, by any secret disposition of the dead body of the said child, whether such child died before, at, or after its birth, endeavour to conceal the birth thereof, shall be guilty of a misdemeanour." The mere avowal of the birth is not sufficient to convict her; she must be proved to have done some act of disposal of the body after the child was dead (R. *v.* Turner, 8 C. & P. 755).

In Scotland, *concealment of pregnancy* is a statutory crime, chargeable when the child born is found dead or is not found at all, and there is no proof of its having been murdered. Pregnancy, up to a period when a child might be born alive, must be proved, and the words "during the whole period of her pregnancy" do not imply that the pregnancy must have continued for the full period of nine months. All that is necessary is that there should be such proof of duration of pregnancy as made a living birth possible. If the accused can bring forward a witness to whom she communicated her pregnancy, or called for assistance at the birth, or (it is believed) can prove that the child was born dead, she is entitled to an acquittal. It has also been said that a woman

ought not to be convicted of "concealment of pregnancy," if at the time of delivery the fœtus do not appear to have reached the seventh month of intra-uterine existence. The birth of a "child," whether dead or alive, is essential; therefore, if the woman accused "can prove that that which she brought forth was not a 'child,' but an abortion, or a *fœtus*, which, from some accident, was in such a condition that, though there had been assistance, it could not have been in a condition to be called 'a child,' then the case is out of the Statute." The Scotch Statute differs from the English on the "concealment of birth" in this, that so long as the woman makes known her pregnancy, the motive for doing so is not considered. Thus, if she make arrangements with any one to conceal the birth, "the Statute is eluded by that very circumstance" (ALISON). The Statute applies to married as well as to single women; but, in the former case, the penalty is seldom enforced unless foul play is suspected.

DEFINITION OF THE TERM "LIVE BIRTH" IN CRIMINAL CASES.

"The entire delivery of a child." There must be an independent circulation in the child before it can be accounted alive (R. *v.* Enoch, 5 C. & P. 539). The entire child must be actually born into the world in a living state (R. *v.* Poulton, 5 C. & P. 329). But the fact of the child being still connected with the mother by the umbilical cord will not prevent the killing from being murder (R. *v.* Reeves, 9 C. & P. 25). To kill a child in its mother's womb is no murder, because the person killed must be "a reasonable creature in being, and under the King's peace." But if the child be injured in the womb, and yet be born alive, and then die as a result of such injuries, it may be murder in the person who inflicted them (R. *v.* Senior, 1 Mood. C. C. 346).

A distinction must be drawn between *medical or physiological life* and *legal life*. A child may have breathed, as it not infrequently does, *before* it is completely born into the world; and this might, in a medical point of view, be considered as a live child, but it is not one legally. The entire delivery of the child is necessary in law; and "it must also be proved that the entire child has actually been born into the

world in a living state, and the fact of its having breathed is not a conclusive proof thereof." The inference unfortunately follows from this ruling, that a mother may kill her child without fear of punishment, if she do so before the entire body has slipped from her.

DEFINITION OF THE TERM "LIVE BIRTH" IN CIVIL CASES.

The evidence of live birth in civil is somewhat different from that required in criminal cases. The viability of the child is determined in Scotland by its *crying;* in France, by its respiration; in Germany, "the LIVE BIRTH of a child is to be held proven when it has been heard to cry by witnesses of unimpeachable veracity present at its birth"; but in England, the pulsation of the child's heart, or any tremulous motion of the muscles, however slight, has been considered as satisfactory proof of live birth.[1]

According to Blackstone, "crying, indeed, is the strongest evidence, but it is not the *only* evidence"; and Coke remarks, "If it be born alive, it is sufficient though it be not heard to cry, for peradventure it may be born dumb."

Signs of Live Birth prior to Respiration, and independent of it.—(1) Negative.—Signs of intra-uterine death, *i.e.* putrefaction, or "intra-uterine maceration," or of such imperfect development that it could not have been born alive. (2) Positive.—Injuries to the child showing that it must have been born alive.

1. NEGATIVE.—*Intra-uterine Putrefaction.*—This condition differs in some remarkable points from putrefaction in air.

The body is extremely flaccid and flattened, the bones of the cranium moving easily on one another. The skin of the hands and other parts of the body bear the evidence of prolonged soaking in fluid. In parts, the skin is whitish, or of a reddish-brown or coppery-red colour, without any trace of green, which is always present when putrefaction takes place in the air. The cuticle may be raised in blisters, and be easily detached from the true skin. The denuded patches are moist and greasy, and exude a stinking, reddish-coloured serous

[1] Fyshe or Fisher *v.* Palmer, in 1806.

fluid. The face is flattened, and the features distorted. In one case that Husband attended of intra-uterine death of the fœtus in a primipara, and where putrefaction was far advanced, the scalp burst during delivery, and the brain was poured out. Should, however, the child be exposed to the air, it may soon acquire the appearances proper to putrefaction in that medium. If the child, immediately after birth, be thrown into water, the putrefactive changes would be like those of intra-uterine decomposition. In this case the lungs must be examined for the evidence of death by drowning.

2. Positive.—Evidence that injuries found on the body could not have been inflicted during birth, or accidentally after birth. On this subject it is scarcely possible to give an opinion one way or the other. All the medical witness can fairly state is, that, from the condition of the lungs, respiration has or has not taken place; that, in the former case, it is not easy to state whether the injuries were the cause of death or inflicted after death.

Appearances showing that a New-Born Child has breathed.—1. Walls of the Chest.—"The vaulting of the thorax is not of the slightest diagnostic value." Casper quotes from Elsässer the following remarks:—"It is irrefutable that the variations in the circumference of the thorax (and, of course, in its diameters) are so considerable that no certain normal mean for a thorax that has breathed, and for one that has not breathed, can be laid down. In most cases the measurements of the thorax are incapable of determining whether the lungs contain air or not. The reason for these variations is, without doubt, to be referred to the congenital differences in the volume of the osseous thorax; partly, also, to the thickness of the soft parts, particularly of the subcutaneous fat and the thoracic muscles; partly, also, to the differences in the degree and amount of the dilatation of the thorax by respiration, with which the distension of the lungs also corresponds," etc.

2. Diaphragm.—The position of the diaphragm may be considered as a good diagnostic sign; for it is found that, in children born dead, the highest point of the concavity is between the fourth and fifth ribs, whereas in those born alive it is between the fifth and sixth. The position of the diaphragm may be affected by the gases produced during putre-

faction, and also, in children who have *breathed*, from distension of the stomach and intestines with gas.

3. Stomach and Intestines.—With regard to the stomach, Tardieu has suggested that the presence of air-bubbles in the glairy mucus usually found in that organ is a sign of live birth, as it can only have arisen from the swallowing of saliva and mucus, aerated by repeated attempts at respiration, probably lasting from five to fifteen minutes. Breslau of Prague, who has further investigated this subject, states that, in children born dead, or who have undergone prolonged intra-uterine putrefaction, there is never any accumulation of gas in the stomach or intestines, and that the presence of gas in these organs is contemporaneous with respiration, and is independent of the ingestion of food. The intestines of newly-born children do not float in water, but rapidly sink in that fluid. As respiration proceeds, the coils of the intestines become distended with gas.

4. Kidneys and Bladder.—The presence of crystals of uric acid in the pelvis of the kidneys and even in the bladder has been suggested as a sign of live birth. Uric acid infarction, as it has been called, usually occurs in from two to ten days after birth, at a period when there are more important signs of live birth than this, even if infarction did not occur, as it does, in still-born infants.

5. Lungs.

(*a*) *Size.*—In the fœtus, prior to respiration, the lungs do not fill the cavity of the chest, and the left lung is never found even partially covering the heart.

After respiration they fill the thorax more or less completely, the amount of distension depending, of course, upon the completeness of the respiratory acts on the part of the child.

(*b*) *Consistence.*—Before respiration has taken place, the lungs feel firm, compact, and resistant, and are of the consistency of liver.

After respiration they are spongy, crepitant, and yielding when pressed between the fingers. They also present a marbled appearance. These signs of respiration are more or less modified by disease, and the *atelectasis pulmonum* of Jörg, jun.

Casper denies the existence of *atelectasis pulmonum* as a distinct disease of newly-born children, and considers that "it

is nothing else than the original fœtal condition, from which it differs in no anatomical respect"—an opinion supported by Meigs, who says "they, in fact, resemble exactly the fœtal lung." It is simply the result of the child dying from some cause before respiration has had time to become fully established, and has possibly been confounded with hepatisation. It must also be remembered that cases are on record of infants having lived for some hours, and then died, yet the lungs sank as a whole, and when cut in pieces.

(*c*) *Colour.*—The colour of the fœtal lungs is "exceedingly various," and it is by no means easy to convey the idea of colour by words. Speaking in general terms, the lungs of children who have *not* breathed are of a reddish-brown liver colour, this colour changing to a brighter red at their margins. In children who *have* breathed, the lungs are of a slaty-blue colour, more or less mottled with circumscribed red patches. This circumscribed mottling is *never* found in perfectly fœtal lungs. When the lungs are inflated artificially, they swell up and present a uniform cinnabar-red colour, destitute of insular marbling. The insular marbling of the lungs is characteristic of lungs that have breathed, and is due to the presence of blood in the arteries and veins surrounding the inflated lung tissue.

(*d*) *Buoyancy in Water.*—Lungs which have respired float in water.

But the objection may be raised that lungs that have *not* respired may yet float from—

1. The result of artificial respiration.
2. The result of putrefaction.

The value of these objections will be discussed in the following pages.

The following Table is given by Tidy :—

Lungs that have not Breathed.	Lungs that have Breathed.
1. Dark in colour (black-blue, maroon, or purple), resembling liver. No mottling.	1. Light in colour (rose-pink, pale pink, light red, or crimson), mottled.
2. Air-vesicles not visible to the naked eye.	2. Air-vesicles distinctly visible to the naked eye, or a lens of low power (say a two-inch, or even a common reading-glass).
3. When squeezed or cut, do not crepitate or crackle.	3. Crepitate or crackle freely.
4. Contain but little blood, therefore little escapes on section.	4. Contain a good deal of blood, which escapes freely on section.
5. The blood present is not frothy, unless there be putrefaction.	5. This blood is freely mixed with air, and therefore appears frothy.
6. Sink in water, unless putrid, and often not then.	6. Float in water; or, at all events, the parts which have been expanded, or have breathed, float. If fully expanded, they will buoy up the heart.
7. Bubbles of gas arising from putrefaction may be squeezed out, and as they escape are usually noted to be of large size.	7. The air cannot be squeezed out by pressure.

Hydrostatic Lung Test.

(Docimasia pulmonum hydrostatica.)

The value of this test, which is a test of respiration and not of live birth, is founded on the supposition that a lung in which respiration has taken place will float if placed in water, and that when this has not occurred it will sink. Admitting that a lung floats as a result of respiration, it has been objected that this is no proof of live birth, for respiration may take place in—

1. The womb, *vagitus uterinus.*
2. The maternal passages, *vagitus vaginalis.*
3. Cases when the head protrudes, the body not yet being born.

With regard to the two first objections, it will be sufficient

to say that, in all the cases of so-called intra-uterine respiration, the respiratory acts have occurred in difficult or instrumental labours, where it is justifiable to suppose that, in the endeavour to remove the child, a certain amount of air may have been unavoidably admitted into the maternal passages. But the cases with which the medical jurist has to deal cannot be classed with these, for in all those brought under his notice delivery has been more or less rapid and unassisted.

To the last objection the same reply may be given, that rapid delivery in doubtful cases must be considered as the rule, and that the time which elapses between the birth of the head of the child and its complete delivery is so short as not to lead to any great error in diagnosis. It is true that the woman may faint with the child half born, and that respiration may thus take place; and it has not yet been decided how many inspirations a child must make to entirely inflate its lungs, or the length of time required to do so.

N.B.—Any pressure exerted on the umbilical cord during the process of delivery gives rise to respiratory acts on the part of the fœtus. The presence of what Casper calls *petechial ecchymoses* beneath the pleuræ, upon the aorta, and even on the heart, are, as a rule, a proof that attempts at respiration have been made. These petechial ecchymoses are sometimes found on the same parts in the drowned. (See "Drowning.")

How is the Hydrostatic Lung Test performed? and What are the Objections to its Use?

As this test was first used, it consisted in placing the lungs, with or without the heart, in water, and then noting whether they sank or floated. A glass vessel, eighteen inches high and twelve in diameter, half filled with distilled water at 60° F., should be used. In summer, water at the ordinary temperature of the room will answer the purpose. To this rough test pressure is now added; the lung, or portions of it, are greatly compressed in a linen cloth, and then thrown into water as before. If the lungs thus compressed float, respiration is held to have taken place; should they sink, the contrary is presumed.

Pressure is used for the following reason:—The air generated by putrefaction, and which may cause the lungs to float, is removed by pressure, but no amount of pressure, short of

entirely destroying the lung tissue, will remove that, the result of respiration or inflation; and between these the medical expert must decide from collateral evidence.

In performing the test—(1) Try if the lungs will float with the heart and thymus gland attached to them. (2) If they will float without the heart, etc. (3) Try if portions will float with or without pressure.

The following are the Objections to this Test:—

1. The lungs may sink as a result of disease.
2. Respiration, even in healthy lungs, may be so imperfect that they may sink.
3. Emphysema pulmonum neonatorum.
4. Putrefaction.
5. Artificial inflation.

1. That in consequence of disease the entire lungs, or portions of them, may sink, and yet respiration may have taken place. Disease of the lung may occur previously to birth or soon afterwards, but it is scarcely probable that the disease would attack every portion of the lung. Parts, doubtless, small in proportion to the diseased part, may yet have been sufficiently inflated to float. The presence of disease is also not difficult of detection.

2. That respiration, even in healthy lungs, may be so imperfect that they may sink. This objection can scarcely be considered valid against the general application of the test, for in these cases there is no known test by which respiration or its absence can be determined. They are, therefore, out of the pale of the test, as they are out of every other mode of investigation.

3. *Emphysema pulmonum neonatorum.*—Emphysema is generally the result of excessive dilatation of the air cells of the lung, rupture of the cell walls, and infiltration of the intralobular areola tissue. This condition may be brought about by—

(*a*) Respiration. (*b*) Inflation.

The fact of the matter is simply this, that the so-called *emphysema pulmonum neonatorum*, or emphysema of new-born children, is nothing more or less than incipient putrefaction, induced by certain unascertained conditions.

Casper sums up his conclusions on this subject in the following words:—"That not one single well-observed and incontestable case of emphysema, developing itself spontaneously within the lungs of a fœtus born without artificial assistance, is known; and it is not, therefore, permissible in forensic practice to ascribe the buoyancy of the lungs of new-born children, brought forth in secrecy and without artificial assistance, to this cause."

4. *Putrefaction.*—It must be admitted as proved that the lungs of new-born children in a state of decomposition will float in water. But this admission does not render the test valueless, for it must be remembered—

(*a*) That air generated by putrefaction is found in bubbles *under* the pleuræ, or in the fissures between the *lobuli* of the lungs, and *not in the air cells* of the lungs.

(*b*) That air as a result of putrefaction can easily be removed by compressing the lungs, or portions of them.

(*c*) That crepitation in putrefied lungs is absent, owing to the fact stated under (*a*).

(*d*) That the lungs are among those organs which putrefy late.

(*e*) That negative evidence may be obtained, if the lungs, in a highly putrescent body, sink in water. The tendency of putrefaction, as above stated, is to cause them to float.

5. *Inflation.*—In the first place, it is to be remarked that to inflate the lungs is by no means an easy task. Elsässer states "that in forty-five experiments performed on children born dead, without opening their thorax and abdomen, only *one* was attended with complete success, thirty-four with partial success, and ten with none whatever; and it must also be remembered that these experiments were conducted without disturbance, and with the greatest care." Professor Gross states his opinion on this subject thus:—"We are decidedly of opinion that artificial inflation of the lungs is a very difficult matter; and we believe that the complete distension of these organs can only be effected where a tube is introduced into the mouth of the larynx." An old pupil once told me that in trying artificial respiration on a still-born child, he desisted from his attempts at resuscitation on finding the air, which he hoped was entering the lungs, escaping from the anus. In the cases that come before the medical expert, the question naturally arises, Who would inflate the lungs? Surely not the mother, who would be only too glad that the child was dead, and who would be in no hurry to resuscitate it. If not the

mother, who else? It has been suggested that some malicious person might inflate them to sustain a charge of infanticide. Is this probable?

The following points may be noticed on this subject:—

(*a*) Known difficulty in inflating the lungs.

(*b*) Absence on the part of the mother of any preparation to save the life of her child.

(*c*) Presence of air in the stomach and intestines, the result of attempted inflation.

(*d*) Bright cinnabar-red colour of the lungs, without trace of mottling.

(*e*) Absence of frothy blood when the lungs are cut into.

(*f*) "When, therefore, we observe the following phenomena, a sound of crepitation without any escape of blood-froth on incision, *laceration* of the pulmonary cells with hyperæria, bright cinnabar-red colour of the lungs *without any marbling*, and perhaps *air* in the (artificially inflated) stomach and intestines, we may with certainty conclude that the *lungs have been artificially inflated.*

It may be further noted that natural respiration is accompanied with, first, the distension of the air cells of the lungs with air; and, second, with an increased flow of blood into the organs, beyond that necessary for their nourishment and growth. They thus increase in absolute weight, while their specific gravity is lessened.

The objections just mentioned apply to the hydrostatic test, as originally employed. It will now be necessary to notice those against the same test when modified by pressure. These are two in number:—

1. That no amount of pressure, short of entirely destroying the lung tissue, can expel the air from a lung that has been inflated, or from one in which respiration has taken place.

2. Pressure is, therefore, no test of natural respiration or of artificial inflation.

In answer to the above, it will only be necessary to refer to what has been already said with regard to the difficulty of inflation, and the more probable event of the condition of the lungs being the result of respiration.

Casper thus sums up the result of his views with regard to the probative value of the *docimasia pulmonaris*:—

"That a child has certainly lived during and after its birth—

"1. When the diaphragm stands between the fifth and sixth ribs.

"2. When the lungs more or less completely occupy the thorax, or at least do not require to be sought for by artificial separation of the walls when cut through.

"3. When the ground colour of the lungs is broken by insular marblings.

"4. When the lungs are found by careful experiment to be capable of floating.

"5. When a bloody froth flows from the cut surface of the lung on slight pressure."

The Lung Test is unnecessary when—

1. The umbilical cord has dropped off, and cicatrisation has followed.

2. Where food is found in the stomach.

3. Where there are evident signs of putrefaction *in utero*.

4. Also in the case of the birth of monsters, or where, from congenital malformation, the possibility of live birth is excluded.

Besides the hydrostatic test, the following have been proposed :—

PLOUCQUET'S TEST. This test is based on the relative weight of the lungs, before and after respiration, to that of the entire body of the child. The variations found in practice between the relative weights render the test worse than useless.

ABSOLUTE WEIGHT OF THE LUNGS. This test consists in a comparison of the weight of the lungs before and after respiration, and it may be stated here that the lungs, prior to respiration, vary in weight from about 400 to 650 grains ; but so much depends on the maturity or immaturity of the child, and degree of respiration, that, like the last, the test is unworthy of confidence.

WREDIN'S TEST.—Dr. Wredin, of St. Petersburg, states that the gelatinous substance found in the middle ear of infants before birth, gradually disappears, to be replaced by air on the subsequent establishment of respiration. Wendt, of Leipzig, from an examination of 300 cases, declares that the gelatinous substance can only be expelled by the establishment of full respiration. The value of this test has been questioned, as some observers have found that in different cases intervals of from a few hours to five weeks have occurred, before the replacement of the gelatinous material by air.

Table showing the Development of the Embryo according to the Lunar Months.

Month.	Length.	Weight.	Observations.
First. 3rd or 4th week.	Four to six lines.	Twenty grains.	The embryo is curved: the mouth on the cephalic extremity appears as a cleft, and the eyes as two black points. Nipple-like protuberances mark the position of the extremities. The heart can be seen, and the liver is disproportionably large.
Second. End of 8th week.	Fifteen to eighteen lines.	Two to five drachms.	The head disproportionably large. Nose, lips, and external parts of generation visible, but sex doubtful. Anus appears as a dark point. Abdomen encloses the internal organs. Extremities project slightly from the trunk. *Ossification* in *clavicle* and *lower jaw* about end of *seventh week*; in *frontal bone* and *ribs* towards end of *eighth week*.
Third. End of 12th week.	Two to two and a half inches.	One to two ounces.	Eyes and mouth closed. Fingers well separated: nails recognisable. The sex can be detected by the aid of a lens. Supra-renal capsules and thymus gland are formed. The cavities of the heart and divisions of the brain distinct. The placenta isolated: the umbilical vesicle, allantois, etc., have disappeared.
Fourth. End of 16th week.	Five to six inches.	Two and a half to three ounces.	The skin rosy and tolerably dense. Sex seen without aid from lens. The mouth is large and open; the umbilicus is near the pubis. Meconium of a greyish-white colour in the large intestines.
Fifth. End of 20th week.	Ten to eleven inches.	Seven to ten ounces, varying in individuals.	From the fifth month the length of the fœtus in inches is approximately *exactly double the number of the lunar months*. The nails are distinct. The head, liver, heart, and

TABLE SHOWING THE DEVELOPMENT OF THE EMBRYO—*Continued.*

Month.	Length.	Weight.	Observations.
			kidneys are disproportionably large. The hair appears as a light down. The meconium is of a yellowish-green colour. Points of ossification, pubis and os calcis.
Sixth. (End of 24th week.)	Twelve to thirteen inches.	One to two pounds.	Down and sebaceous matter cover the skin. The colour of the body is a cinnabar-red, and the umbilicus is farther from the pubis. The meconium is darker in colour; and the scrotum is empty, the testes being close to the kidneys. The pupillary membrane is still present.
Seventh. (End of 28th week.)	Fourteen to fifteen inches.	Three or four pounds.	The skin is of a dirty-red colour; the hair about half an inch long, and plentiful. Membrana pupillaris disappearing; eyelids non-adherent. The large intestine quite full of dark olive-green meconium. Fontanels distinctly felt. Liver still large, of a dark-brownish colour.
Eighth. (End of 32nd week.)	Fifteen to sixteen inches.	Three to five pounds.	The skin, covered with soft hair, is more of a rosy flesh-colour. Disappearance of the pupillary membrane, and descent of the testicles into the scrotum. The open vulva exposes the clitoris to view. The nails almost reach the tips of the fingers.
Ninth. (End of 36th week.)	Sixteen to eighteen inches.	Six pounds.	The head covered with hair; the down on the body disappearing. The scrotum corrugated, and the vulva closing.
Tenth. (End of 40th week.)	Eighteen to twenty inches.	Seven to nine pounds.	Well-known signs of maturity.

TABLE GIVING THE MEASUREMENTS, ACCORDING TO THE MONTHS, OF THE EXTREMITIES OF THE FŒTUS IN THE ORDER OF THEIR DEVELOPMENT.

	Third.	Fourth.	Fifth.	Sixth.	Seventh.	Eighth.	Full Period.
Humerus	$3\frac{1}{2}$ lines.	8 lines.	13-15 lines.	16 lines.	20-22 lines.	23-24 lines.	3 inches.
Radius	$2\frac{1}{2}$,,	8 ,,	12 ,,	16 ,,	17 ,,	18-19 ,,	2 ,, 8 lines.
Ulna	3 ,,	8 ,,	13 ,,	17 ,,	18 ,,	22-23 ,,	2 ,, 10 ,,
Femur	2-3 ,,	4-5 ,,	12 ,,	17 ,,	19-21 ,,	24 ,,	3 ,, 6 ,,
Tibia	2-3 ,,	4-5 ,,	12 ,,	17 ,,	19-21 ,,	21-23 ,,	3 ,, 2 ,,
Fibula	$2\frac{1}{2}$,,	...	12 ,,	17 ,,	19-21 ,,	21-23 ,,	3 ,, 1 ,,

TABLE SHOWING THE MAXIMUM AND MINIMUM DIMENSIONS OF THE OSSEOUS NUCLEUS OF THE INFERIOR FEMORAL EPIPHYSIS FROM THE SEVENTH MONTH OF INTRA-UTERINE LIFE TO TWO YEARS AFTER BIRTH.

	INTRA-UTERINE.			EXTRA-UTERINE.						
				Days.			Months.			
	Seventh.	Ninth.	Mature.	1-8	9-15	16-28	1	3-6	7-12	12-24
Maximum	...	2 lines.	4 lines.	$3\frac{1}{2}$ lines.	$3\frac{1}{2}$ lines.	$2\frac{1}{2}$ lines.	5 lines.	4 lines.	8 lines.	7 lines.
Minimum	...	...	$\frac{3}{4}$ line.	1 line.	$\frac{3}{4}$ line.	$1\frac{1}{2}$,,	2 ,,	2 ,,	3 ,,	5 ,,
No. of Children examined 125	31	9	52	8	3	2	9	3	6	2

Table showing the Signs of Maturity of Child at Birth.

As regards—

1. *Average Length of Body.*—Nineteen inches.
2. *Average Weight of Body.*—About seven pounds.
3. *Eyes.*—The pupillary membrane is not found in the mature child.
4. *Navel.*—Said to be exactly midway between the pubis and the ensiform cartilage.
5. *External Genitals.*—Testicles found in the scrotum, and the labia majora cover the vagina and clitoris.
6. *Os Femoris.*—Ossification of the inferior femoral epiphysis. The osseous nucleus measures from three-quarters of a line to three lines in diameter.

CAUSE OF DEATH TO THE FŒTUS.

Death may be due to—

I. Immaturity on the part of the fœtus.
II. Complications occurring during or immediately after birth.
III. Congenital disease in one or more of the fœtal organs.
IV. Neglect or exposure, constituting "Infanticide by Omission."

I. Immaturity on the part of Fœtus.—From some cause or another, the child may die immediately after birth, in spite of every attempt to save it. In many of these cases no disease adequate to account for death can be detected.

II. Complications occurring during or immediately after Birth.—(1) Unavoidable or inherent in the process of parturition. (2) Induced with criminal intent, constituting "infanticide by commission."

1. *Unavoidable or Inherent in the Process of Parturition.*—The immediate cause of death may be either maternal or fœtal. In the former, the presence of tumours in the pelvic passages, or disease of the bones, causing a narrowing of the canal, may lead to fatal compression of the head of the child. Death may also be due to protracted labour from debility on the part of the mother, or she may suddenly faint after delivery. A congested state of the brain may be present in these cases. In the latter (fœtal), pressure on the umbilical cord from malposition of the child during labour, or an abnormal increase in the size of the head, may cause death. There is also a greater mortality, both during and after delivery, among male than female children. The child may be also accidentally suffocated in the fæces of the mother, or in a fold of her dress; or it may

be born while the woman is straining at stool, and be drowned in the contents of the pan. Husband once met with a case of accidental death of a child from suffocation in the drawers of the mother, who persisted, from motives of delicacy, in wearing those articles of dress during her confinement. Death may also result from strangulation, occasioned by the pressure of the funis round the child's neck. The death in this case can scarcely be considered as due to strangulation, as the child had never breathed, but it is probably the result of the arrest of the flow of blood along the cord, from the tightness of the folds round the neck. Some congestion of the brain may, however, be found resulting from the pressure on the vessels of the neck. Lastly, death may ensue from a fall on the floor in cases of sudden and quick labours, especially if the woman be in the erect posture at the time of delivery.

2. *Induced with Criminal Intent.*—Infanticide by commission, was the death due to violence? The answer to this question is by no means easy. In all doubtful cases the attendant circumstances must be taken into consideration. A woman may unintentionally injure her child in her efforts to drag it from her. The presence of respiration, more or less complete, is strongly presumptive against the death being the result of accident. But even here considerable caution is necessary, for the injury may not be immediately fatal, although accidentally inflicted, sufficient time elapsing between its infliction and the death of the child to allow of respiration. Foreign bodies found in the mouth and fauces are also corroborative of death by violence. A case is recorded in which the child's fauces, upper portion of the œsophagus, the larynx, and the trachea were closely packed with a coarse green sand, and yet the lungs sank when the hydrostatic test was applied to them. There was nothing to show when the packing of the fauces was effected. If dead, Why? If alive, How was respiration prevented during the operation? Strangulation may be produced by the constriction of the umbilical cord round the neck, and for this reason marks round the child's neck cannot always be ascribed to intentional violence. Of 327 cases collected by Elsässer, in which the cord was from one to four times round the children's necks, there was not in a single instance any mark of the cord perceptible, even though in some cases the cord had to be cut to permit the completion of

labour. With regard to marks round the neck of a new-born child, Casper remarks that it is possible "to mistake the folds of the skin, produced by the movements of the head, and which remain strongly marked in the solidified fat, and are very prominent, particularly in short necks, for the marks of the cord." The *mark* left by the *funis* is broad, corresponds with the breadth of the cord, runs without interruption round the neck, and is everywhere quite soft, and never excoriated. Ecchymoses may be present, irregularly following the line made by the cord. On the other hand, "a mummified, parchment-like, unecchymosed depression points in every case to strangulation by a hard, rough body," and this more especially if there be any abrasion of the cuticle or laceration of the skin. Death, sometimes ascribed to strangulation, is probably the result of suffocation, and happens thus: any pressure exerted on the cord cuts off the blood from the placenta to the fœtus, and gives rise to respiratory attempts on the part of the child, and the child dies from suffocation, or from the engorgement of the lungs with liquor amnii drawn into them at every effort to breathe. An infant may be poisoned. This cause of death is very rare, but deaths have resulted from the use of poisonous gases. While on this subject it may be advisable to state here that ulcerations have been found in the stomach and intestines more or less accompanied with a collection of dark-brown or black bloody fluid, which have given rise to suspicions of poisoning in infants to all outward appearances quite healthy. An infant may be thrown into water and drowned. No traces of this mode of death would be discoverable in the infant unless respiration had taken place prior to its immersion. The plea of accidental drowning in a cesspool or water-closet pan may be put forward; it is therefore well to examine the cord. Has a ligature been placed upon it? Has it been cut by a sharp instrument? The nature and character of the fluid found in the stomach should be noted.

Fractures of the skull may happen—

1. *In the Womb.*—The parturient female may fall from a considerable height, and thus cause injury to her child. These cases are of no judicial importance, as the presence of intra-uterine putrefaction or an examination of the lungs will at once show that the child has not breathed. It must be borne in mind, however, that dislocations may take place in the

womb, and this fact may be brought forward in defence. The history of the case, and the absence of any other signs of violence, will decide the truth or falsity of the plea.

2. *During Labour.*—Fracture of the cranial bones during labour generally occurs in difficult and protracted labours, which, from this very cause, seldom become the subject of judicial inquiry. In some cases the defective ossification of the bones of the skull may give rise to fractures, which may lead to dangerous mistakes. This deficiency in the process of ossification is thus described by Casper:—"If the bone in question is held up to the light, this is seen to shine through the opening, which is closed only by the pericranium. When the periosteal membrane is removed, the deficiency in the ossification is seen in the form of a round or irregularly circular opening, not often more than three lines in diameter, though frequently less; its edges are irregular and serrated: these edges are *never depressed, as is the case in fractures;* and neither they nor the parts in their neighbourhood are ever observed to be ecchymosed." The child in these cases may breathe for a short time, and then die without any apparent cause.

3. *By Falls.*—It is beyond doubt possible for a child to be born so precipitately as to fall on the floor and be severely injured, and that even fatally. In cases of alleged precipitate birth, to account for injuries found on the child, the following points should be remembered, and will assist in forming a diagnosis:—

1. In Favour of Precipitate Birth and Accidental Injury.

(*a*) Rupture of the Umbilical Cord.—In all cases it would be advisable to measure the length of the cord, and then the distance of the vulva from the ground, allowing of course for the woman not being quite erect at the time of delivery owing to a separation of the legs. A disproportion between the two measurements may or may not account for the rupture of the cord. The following measurements may be taken:—Usual length of cord, eighteen to twenty inches; distance of vulva from the ground, twenty-six inches, but allowing for stooping, two-thirds of the above. To the length of the cord must be added about nine inches, the distance from the navel to the top of the head of the child. Thus, a fall of about thirty inches will put no strain on the cord. A case is on record of a rupture of the cord taking place while the woman was in a *recumbent* position, but in that case the labour was precipitate, and the cord very short and small.

(*b*) Placenta not detached from the child.

(*c*) Fracture of the parietal bones; the fracture radiating into the

frontal and squamous portion of the temporal bone. In experiments on twenty-five children dropped from a height of thirty inches, one parietal bone was found fractured in sixteen of the cases; both parietals, in six cases. The fractures in most cases occurred about the parietal protuberances. It must be remembered that the children were dead, and that it is easier to fracture the skull of a live infant than that of a dead one.

(*d*) Imperfect ossification of the bones of the skull.

(*e*) Absence of other injuries.

FIG. 21.—Photo-micrograph of human milk, ×250. (R. J. M. Buchanan.)

2. In Favour of Criminal Violence.

(*a*) The fact of the umbilical cord being divided by some sharp instrument and not torn. A caution must be here inserted, for Taylor mentions a case where rupture of the cord occurred in such a manner that it could not be decided whether it had been intentionally cut or torn.

(*b*) Extensive fracture of one or more of the bones of the cranium.

(*c*) Fracture and dislocation of the neck.

(*d*) Presence of incised wounds, and other evidence of violence.

N.B.—In all doubtful cases, a guarded opinion should be given, stating simply that the dissection does not reveal anything contrary to the statements offered as to the cause of death.

III. Congenital Disease in one or more of the Fœtal

ORGANS.—In all cases the presence of congenital disease must be sought for.

IV. NEGLECT OR EXPOSURE, CONSTITUTING "INFANTICIDE BY OMISSION."—Under this head may be mentioned the following :—

(*a*) Neglecting to place the child in such a position that it may breathe freely.
(*b*) Neglecting to protect the child from extremes of cold or heat.

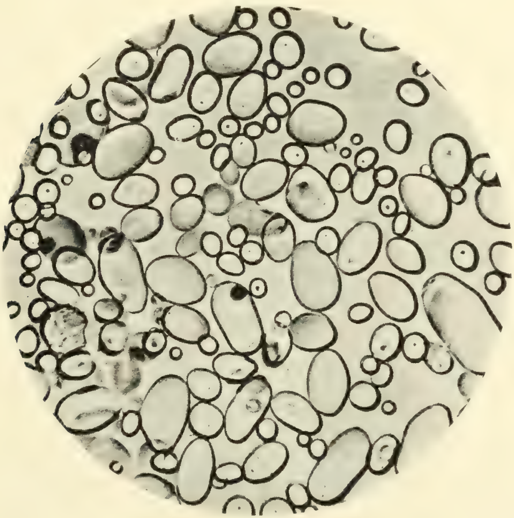

FIG. 22.—Photo-micrograph of starch granules, ×250 (potato). (R. J. M. Buchanan.)

(*c*) Neglecting to feed it with the food appropriate to its age. (See Signs of Death from Starvation, pp. 140 *et seq.*)
(*d*) Neglecting to tie the umbilical cord.

To give answers to these questions will in many cases be impossible, and each must be decided by such circumstances as present themselves in each individual case. For instance, if the body is found stiff, blanched, naked or nearly so, lying on the ground, the vessels of the interior gorged with blood, whilst the superficial vessels are contracted and can be seen only with difficulty ; at the same time, the hydrostatic test shows that respiration has taken place, and the absence of all external or

internal causes—the probability is in favour of death by cold. In close relation with the present subject is the question—

Has the Infant bled to Death?—Fatal hæmorrhage from the cord may occur, especially if it be divided by a sharp instrument close to the body of the child. As a rule, hæmorrhage does not occur from a ruptured cord. (The signs of death from hæmorrhage have been noticed, page 88.)

How Long did the Child survive its Birth?—The answer to this question is by no means easy, and the data on which a decision can be based are not very reliable. The presence or absence of the *vernix caseosa* should be noticed. In still-born children the closed eyelids, when raised, do not remain open; in the live-born, on the other hand, the eyes remain half open even after repeated attempts to close them. Another guide to the determination of the length of time the child survived its birth may be found in the absence or presence of the meconium in the intestines. The meconium—from its resemblance to inspissated poppy juice—is found in the large intestine as a dark-greenish pasty mass, more or less filling that portion of the bowel. In the upper portions of the intestines it varies from a light-yellowish or greyish to a greenish-brown colour, till in the large intestine it assumes the colour and consistence above mentioned. It is generally discharged by the infant in from four or five to forty-eight hours after birth. In breech presentations it may be passed during the process of delivery, although the child be still-born; but its entire absence from the intestines is presumptive of existence for some days after birth.

The following are some of the points to be considered in forming a diagnosis:—(1) Changes in the skin. (2) Changes in the umbilical cord. (3) Changes in the circulatory system.

1. *Changes in the Skin.*—Exfoliation of the cuticle. The time at which this occurs is so variable as to be of little value in a medico-legal inquiry.

2. *Changes in the Umbilical Cord.*—Mummification of the cord is not of the slightest value as a proof of extra-uterine life; but the separation of the cord which occurs between the fourth and seventh day, especially when cicatrisation has taken place, is a sure sign that the child must have lived four or five days at least. Two other appearances of some value may also be noted, namely:—

(*a*) In fresh bodies, the appearance of a bright-red ring about a line in breadth, which surrounds the insertion of the cord, and which is formed within the uterus.

(*b*) A similar red ring, about two lines broad, around the insertion of the cord, accompanied with "*thickening, inflammatory swelling of the portion of the skin affected, and slight purulent secretion from the umbilical ring itself.*" This latter condition Casper considers as affording "*irrefragable proof of the extra-uterine life of the child.*"

3. *Changes in the Circulatory System.*

(*a*) Ductus Arteriosus.—Arterial duct. A contracted condition of this duct is of no value as a proof that a child has survived its birth; for the duct is liable to become contracted, and even obliterated, before the birth of the child.

(*b*) Ductus Venosus.—Nothing certain is known as to the exact time when this duct closes; the condition of the vessel is, therefore, of no assistance in determining the possibility of the child having survived its birth. The duct has been found closed in a still-born child; and in one child, which lived for a quarter of an hour, both the *ductus arteriosus* and the *foramen ovale* were found closed. Cases are also on record in which the fœtal channels were found open after thirty days of extra-uterine life.

(*c*) Foramen Ovale.—What has been said of the preceding may be said with regard to the foramen ovale.

N.B.—To sum up, therefore, in the fewest words, any attempt at forming an opinion on the *docimasia circulationis* may result in a fatal error on the part of the medical witness, as it is impossible to determine with any accuracy by days the period of their closure. As a general statement, however, the following, according to Bernt and Orfila, is the order in which obliteration of the fœtal vessels takes place:—(1) The umbilical arteries. (2) Ductus venosus. (3) Ductus arteriosus. (4) Foramen ovale.

TABLE SHOWING HOW LONG A NEW-BORN CHILD HAS LIVED.

	At Birth, but before Respiration.	From 1 to 24 Hours.	From 2 to 3 Days.	From 3 to 4 Days.	From 4 to 6 Days.	From 6 to 12 Days.
Skin.	As a rule, very red, soft, smooth, and covered with a whitish, fatty, sticky coat (*vernix caseosa*).	The skin is firmer and rosy, and the vernix caseosa not so white.	The skin assumes a yellowish tint. Sometimes on the abdomen and base of the chest, the epidermis shows signs of approaching exfoliation.	The icteric colour of the skin is more marked. Exfoliation of the skin has begun over belly and base of the chest.	The exfoliation of the skin extends from the groins to the axillæ, and between the shoulders. The epidermis is detached in strips, in scales, or as a firm powder.	The exfoliation of the skin has extended to the extremities.
Head.	Presence of caput succedaneum.	...	The caput succedaneum has disappeared, leaving only a slight ecchymosis.	...	...	...
Umbilical Cord.	Is fresh, firm, bluish, roundish, more or less spongy. The ductus arteriosus is four to six lines long. Its dia-	The umbilical cord is withering, and the calibre of the arteries is beginning to diminish from the thick-	The cord is brown from its extremity to its base, is less moist, and already shows signs of mummi-	The cord is of a brownish-red colour, flattened and distorted. The vessels are twisted like a gimlet. The ar-	The cord is detached from the abdomen, the membranes first, then the arteries, and last, the vein. The arteries and	If the cord was thin, cicatrisation is complete before the tenth day. The arteries, the vein, and other fœtal

TABLE SHOWING HOW LONG A NEW-BORN CHILD HAS LIVED—*Continued.*

	At Birth, but before Respiration.	From 1 to 24 Hours.	From 2 to 3 Days.	From 3 to 4 Days.	From 4 to 6 Days.	From 6 to 12 Days.
	meter is double that of each of the branches of the pulmonary artery.	ening of their walls.	fication. The vessels are not easily made out, being flattened, and contain a fine clot more or less contracted.	teries are in great part obliterated, the calibre of the vein and ductus venosus is diminished, but they and the foramen ovale are still open. The circumference of the ring is injected and begins to show signs of inflammation, with the discharge of a sero-purulent fluid at the base of the cord.	the vein are quite obliterated. The ductus arteriosus and foramen ovale diminished in size are still open.	canals are obliterated. If the cord was thick, a sero-purulent discharge may continue to the twenty-fifth or thirtieth day.
The Large Intestine.	The large intestine contains meconium.	The meconium is discharged, but the large intestine still contains thick greenish mucus.	The green mucus which covered the intestine is detached in places.	The green mucus almost absent.	The green mucus quite absent.	..

Synopsis.

1. Infanticide is not regarded as a specific crime.

2. To be tried by the same rules of evidence as apply to murder.

3. The law presumes that every child is born dead, till proof to the contrary is given.

4. Onus of proving live-birth devolves on the prosecution.

5. The body need not be found in order to obtain conviction of the suspected party, if not of infanticide, at least of concealment of birth.

The medical evidence, however, depends on the body being found and examined.

The medical witness may be examined on one or more of the following points:—

(1) The recent delivery of the accused.

(For "Signs of Recent Delivery," see page 166.)

(2) Maturity of the child found.

(3) Was the child still-born or live-born?

(4) Cause of death.

(5) Lastly, as to the mental condition of the mother. Puerperal mania, etc.

6. In absence of proof of infanticide, the woman, in England, may be tried for *concealment of birth*, that is, disposing secretly of the body, whether the child be born dead or alive.

7. In Scotland, a woman may be tried for *concealment of pregnancy* when the child is dead or missing, if she do not call for or make use of help or assistance in the birth; but the case is quashed, if the child be shown alive by the mother to others.

CHAPTER XV.

INHERITANCE — LEGITIMACY — IMPOTENCE AND STERILITY—SURVIVORSHIP—MALPRAXIS AND NEGLECT OF DUTY—FEIGNED DISEASES—EXEMPTION FROM PUBLIC DUTIES—WILLS.

INHERITANCE.

This subject will be discussed under the following heads:—(1) The child must be born alive. (2) The child must be born during the lifetime of the mother. (3) The child must be born capable of inheriting. (4) Tenancy by courtesy, and *possessio patris*.

1. The Child must be born alive.—This has been discussed in the preceding section.

2. The Child must be born during the lifetime of the mother.—Death terminates the marriage contract. Would a child born after the death of the mother, and therefore not during marriage, be entitled to inherit?

On this point Lord Coke writes:—"If a woman, seised of lands in fee, taketh husband, and by him is bigge with childe, and in her travell dyeth, and the childe is ripped out of her body alive, yet shall he not be tenant by the curtesie, because the child was not born during the marriage nor in the life of the wife; but in the meantime her land descended."

It appears from this that the husband is not entitled to the life-rent.

3. The Child must be born capable of inheriting.—Monsters cannot inherit according to law. Blackstone says:—"A monster which hath not the shape of mankind hath no inheritable blood," and cannot, therefore, inherit; but, "if it hath human shape, it may be an heir."

Buffon classes monsters under three divisions:—(*a*) Monsters

by excess of organs. (*b*) Monsters by defect of organs. (*c*) Monsters by alteration or wrong position of parts.

A hermaphrodite inherits, or not, property according to the prevailing sex.

4. **Tenancy by Courtesy and *Possessio Patris*.**—"When a man marries a woman seised of an estate of inheritance, and has by her issue *born alive*, which was capable of inheriting her estate; in this case he shall, on the death of his wife, hold the lands for his life as tenant by the courtesy of England."

There is yet another case bearing closely on this subject, known in law as *possessio patris*. On this subject Mr. Amos writes:—"In the event of a man twice married dying, and leaving a daughter by each marriage, his estate would be equally shared by the daughters of the two marriages; but if we suppose that there is also a son by the second marriage, born in a doubtful state, the legal effect of his momentarily surviving birth would be to disinherit the daughter of the first marriage entirely, and transfer the whole of the estate to the daughter of the second marriage, she being sister to the male heir, while the daughter of the first marriage is only half blood."

In both of these cases proof of live birth, as before mentioned, is of the slenderest kind.

A fœtus in the womb (*en ventre sa mère*) may—(*a*) Have a legacy or estate made over to it. (*b*) A guardian assigned to it. That these conditions may take effect, it must be born alive. (*c*) Be an executor. To exercise this *post partum* function, the child must in England have attained the age of twenty-one.

LEGITIMACY.

Every child born in wedlock is presumed to have the husband of the woman as its father; but this presumption may be denied for the following reasons:—

1. Absence or death of the reputed father.
2. Impotence or disease in the reputed father, preventing matrimonial intercourse.
3. In the case of a premature delivery in a newly married woman.
4. Want of access.
5. The paternity of the child may be disputed when the woman marries immediately after the death of her husband.

In Scotland, a child is held to be legitimate if born ten lunar months after the death or absence of its alleged father; and the absence of the supposed father must continue till within six lunar months of the birth of the child, to prove its illegitimacy.

In the same country, a child born before marriage is rendered legitimate by the subsequent marriage of the parents. This is not the case in England.

A child born during wedlock is legitimate, although the date of conception may be before marriage. A child born after the death of its mother is held to be legitimate. A child may, as Taylor remarks, be conceived before marriage, and born after the death of the mother, and yet be legitimate, though neither conceived nor born in wedlock.

The Code Napoleon prohibits the contraction of a second marriage until ten months after the death of the first husband; and this is also the case in Germany. The Anglo-Saxon law prohibits re-marriage for twelve months. In Britain no time is fixed by law.

Duration of Pregnancy.—The consideration of this subject is of importance in its relation to the legitimacy of a child.

The natural period of human gestation is usually stated at forty weeks, ten lunar or nine calendar months, or 280 days. In Prussia, the period is extended to 302 days, and in the Code Napoleon to 300; in Scotland, ten months is held as the limit.

The duration of human gestation is subject to considerable variation; in some females it is always protracted; in others, always premature. Several modes of calculation are adopted by women:—

1. Ascertained date of impregnation from one coïtus.
2. Supposed sensations of female at time of conception.
3. Suppression of the catamenia.—This is open to the objection, that causes other than that of impregnation may arrest them. The catamenia may be stopped by cold or other causes for two or three months, and then, before their return, pregnancy may occur, thus upsetting all calculations. The usual mode of calculation is from two weeks after the last menstruation, and the period so fixed is corrected by the time at which quickening occurs.
4. Period of quickening.—(*a*) Quickening supposed when pregnancy is absent. (*b*) Pregnancy without quickening. (*c*) Variations in the time of its occurrence.

Whichever may be the mode of calculation adopted, it may be stated that, as a rule, the period of human gestation is from 275 to 280 days, and that cases of alleged pregnancy beyond 300 days must be received with considerable caution.

The pregnancy of the Countess of Gloucester was held, in the reign of Edward II., to be legitimate, although her husband had been dead one year and seven months at the date of the application.

Premature Births.—The question may be asked, At what period of gestation may a child be born viable—that is, capable of living and attaining to maturity? Seven months, or 210 days, is considered as the limit; but cases have been recorded of children born at six months being reared. The Roman law admitted the legitimacy of seven-months' children. (For the Signs of Immaturity, see "Table of the Development of the Embryo," pp. 191 *et seq.*)

Superfœtation.—This term is used to imply the conception of a second embryo in a woman already pregnant, and the birth of two children at one time, differing considerably in their maturity, or of two births, a considerable period of time elapsing between each. The possibility of this occurrence has been doubted.

Churchill, in his work on Midwifery, writing on this subject says:—"In conclusion, I would say—(1) That the theory of superfœtation is *unnecessary* to explain the birth of a mature fœtus and a blighted ovum, of a mature and immature fœtus born together or within a month of each other, or of fœtuses of different colours, as they may reasonably be supposed to be the product of one act of generation, or of two nearly contemporaneous. (2) That, in cases of double uterus, it is possible for a second conception to take place, and—judging from the subsequent birth of the second child in the only case on record—at a later period than the first. (3) That, in the remaining cases, where one mature child succeeded the birth of another after a considerable interval, we have no proof of a double uterus in any, and positive proof that in one case it was single; and that to the explanation of these cases no theory as yet advanced is adequate, that of superfœtation being opposed by physical difficulties which are insurmountable in the present state of our knowledge."

The late Dr. Matthews Duncan has, however, shown that

the mouth of the womb is not immediately closed by conception, and that the communication between the vagina and ovary is not destroyed for some months after impregnation, and that there is no impediment to the ascent of the spermatozoa.

The late Dr. Milne, while admitting this form of pregnancy as possible, though very rare, remarks:—"This variety we should not think due so much to mechanical hindrances as to the absence of proper ovules. It would imply extraordinary vigour were perfect ovulation to be achieved for any length of time after impregnation."

IMPOTENCE.

Impotence in the male may arise from—(1) Functional causes. (2) Organic causes.

1. Functional.—Excessive use of alcoholic stimulants, excessive venery, masturbation, and certain debilitating diseases.

2. Organic.—Malformation of the genital organs, deficiency of the penis, fistula *in perineo*, or malformation of the urethra —*hypospadias*—especially when the opening of the urethra is at a considerable distance from the glans. Absence of the testicles from the scrotum does not necessarily imply incapacity for procreation, for persons (*crypsorchides*) in whom the testicles are retained in the abdomen have been capable of begetting children. Cancer of the testicle, or the presence of any other organic disorganisation of the gland, may be considered as a bar to procreation; but even removal of the testicles after puberty does not destroy the power of procreation for a short time after their removal, and men have been known to enjoy the power of copulation for ten years after the operation of castration (Sir A. Cooper). Sterility may be present without impotency.

STERILITY.

Sterility in the female may arise from—(1) Organic causes. (2) Functional causes.

1. Organic.—Absence of the ovaries, uterus, or vagina, imperforate hymen, tumours in the vagina, etc. Dr. Ogston, in referring to this subject, states:—"If I may judge from

what I have since met with in the dead-house, these last affections (fibroid of the uterus), and also obstructions of the fallopian tubes, seem to be usual in prostitutes, and may account in these instances, independently of other alleged causes, for their frequent sterility."

2. **Functional**. Extreme debility—though this is not always an impediment, for some weak, debilitated women conceive rapidly. Constant leucorrhœa may be a cause of sterility; so also may dysmenorrhœa, menorrhagia, and amenorrhœa. Husband successfully treated a lady for profuse leucorrhœa who had not borne a child for nine years; she then bore two children in rapid succession. After the birth of the last, the leucorrhœa returned, which she prefers to the possibility of another pregnancy. It must also be borne in mind that women may be sterile with one man and fertile with another, as in the case of two men who, travelling together with their wives to drink the waters of a celebrated spring on the Continent, accidentally and unconsciously changed wives at an inn, when both wives became pregnant. Husband met with the case of a lady who was married for ten years without issue, but who, on contracting a second marriage, bore children rapidly.

To sustain an application for divorce on the ground of impotence, the cause or causes must have existed before marriage. In one case a nullity of marriage was granted because every attempt at sexual intercourse brought on an attack of hysteria in the wife (H. *v.* P., 3 P. and M. 126).

A medical man may be required to ascertain the capability or incapability of a man for sexual intercourse in—(1) Cases of contested legitimacy. (2) Suits for divorce. (3) Accusations of rape.

Unless there be absolute deformity, or other positive physical cause, no medical man is justified in asserting that impotence or sterility exists.

SURVIVORSHIP.

The question of survivorship is not infrequently raised when a mother and her new-born infant are found dead, or where several persons have perished by a common accident. In the first case the mother is generally presumed to have lived

longest; and this presumption may be borne out by the fact of the delivery being premature, or if there be considerable disproportion between the size of the child and the maternal passages. As pointed out before, important civil rights may depend upon the question as to the live-birth of an infant; and the husband's rights to be *tenant to the courtesy* will, of course, depend upon the view taken as to the probable survivorship or not of the child.

With regard to the second question, much will depend upon the relative ages and strength of the individuals. Sex will also have to be taken into consideration. In the case of one or more persons found dead, either from wounds or other causes, the fact of some being warm and others cold, the presence of the *rigor mortis* in one and absence in the other, will point to the probable survivorship. The severity of the wounds and injuries to large arterial trunks must also be considered. (See test case, Underwood *v.* Wing, 1 Jur. N.S. 169.) In this case a man, his wife, and three children were washed overboard and drowned, one child, however, being seen alive a few minutes after the others were submerged. The question at issue was, Did the husband survive the wife, or the wife the husband? and on this Wightman J., in summing up, said: "We may guess, or imagine, or fancy, but the law of England requires evidence, and we are of opinion that there is no evidence upon which we can give a judicial opinion that either survived the other; in fact, we think it unlikely that both did die at the same moment of time, but there is no evidence to show who was the survivor." Verdict for the plaintiff.

MALPRAXIS AND NEGLECT OF DUTY.

A medical man is liable to a civil action for damages who, by a culpable want of care and attention, or by the absence of a competent degree of skill and knowledge, causes injury to a patient. And it is not necessary that the patient should have employed or was to have paid him, provided always that there be no negligence or carelessness on the part of the patient. Lord Chief-Justice Tindall remarks: "Every person who enters into a learned profession undertakes to bring to the exercise of it a reasonably fair and competent degree of skill." It has also been decided that if the defendant acted honestly,

and used his best skill to cure, and it does not appear that he thrust himself in the place of a competent person, it makes no difference whether he was at the time a regular physician or surgeon or not (R. *v.* Van Butchell; R. *v.* Williamson, etc.). A surgeon does not undertake to perform a cure, nor does he profess to bring the highest professional skill into the consideration of the case; but he does undertake to bring a fair and reasonable amount. The degree of skill required by law is good common sense, or such knowledge as the operator had, joined with a good purpose to help the afflicted, even if such interference rendered the patient a cripple for life. "It would be dreadful," says Hullock B., "if every time an operation was performed an individual was liable to have his practice questioned." "So, if a physician or surgeon give his patient a potion or plaster to cure him, which, contrary to expectation, kills him, this also is neither murder nor manslaughter, but misadventure." A medical man is only liable for gross negligence, not for every slip he may make; but the distinction between criminal and actionable negligence cannot be defined; but it appears that the negligence must be so gross as to come under the legal meaning of the word "felonious."

FEIGNED DISEASES.

Human ingenuity is not wanting among those who, for private ends, pretend to be suffering from disease. The soldier or sailor, anxious to escape the dangers of active service, finds a ready means of evading his duties by shamming; the prisoner, in order to lighten the burden of his punishment, does the same. A man declares himself impotent to save the expense of keeping an alleged bastard child, or to avoid punishment for rape. Beggars appeal to the public by feigning some painful disease, and incautious benevolence becomes the dupe of the clever impostor.

Any attempt at classification is here out of the question, nor does it appear necessary to give a long list of diseases which have been feigned, or the means that have been employed by artists in deception. To give some general hints for guidance is all that will be attempted here, leaving matters of detail to the acumen of the medical examiner, who, if in active

practice, will have many opportunities of testing his powers of discernment :—

1. Never be satisfied with one visit, but pay a second at a short interval, and unannounced.

2. Have the patient carefully watched in the interval of your visits.

3. Examine each organ of the body separately, carefully comparing the state of each with the symptoms described by the patient.

4. Note the discrepancies in the statements of the patient as to his symptoms and their known occurrence in real disease.

5. Sometimes ask questions the reverse of his statements, or take his statements for granted, when in all probability he will contradict himself.

6. Remove all bandages and other dressings.

7. The administration of sham physic, or the suggestion of some heroic mode of treatment ; the application of the actual cautery may have a beneficial effect.

8. Pay little attention to the reports of bystanders, or of the culprit's fellow-prisoners.

9. Anæsthetics may be employed, if necessary, for the purpose of detection.

10. The motives of deception should be inquired into, and borne in mind, in the examination of all cases.

EXEMPTION FROM PUBLIC DUTIES.

The existence of certain diseases may be claimed as a bar to active service, both in a civil and in a military capacity ; and the opinion of a medical man may be required as to the fitness or unfitness of the individual for the service from which he claims exemption. In giving certificates of this nature, the medical practitioner cannot be too guarded in wording them ; and each case must be treated on its merits, so that strict justice may be done.

Among the diseases which may incapacitate a man for active employment may be mentioned—syphilis ; hernia ; phthisis ; affections of the eyes, attended with dimness of vision, or colour blindness ; varicose veins ; and some other diseases. For the army, a man is not considered fit for active service until he is twenty-one years of age.[1]

WILLS.

Although a medical man, as a rule, should refuse to draw up a will, still there are occasions when his doing so may save

[1] See Aitken's *Growth of the Recruit and Young Soldier.*

much litigation and expense. The following directions may therefore be of use :—

1. Let the wishes of the testator be expressed in the plainest and simplest words, avoiding all expressions that seem to admit of another meaning than the one intended.

2. All alterations in the will should be initialled.

3. Do not scratch out a word with a knife, and no alteration must be made after the will is *executed*.

4. Two witnesses are necessary, who must both be present and sign the following attestation at the end of the will, or on each sheet if more than one sheet of paper be used :—"Signed by the testator (or testatrix, as the case may be) in the joint presence of us, who thereupon signed our names in his (or her) and each other's presence."

5. Add address of witnesses.

6. A clause appointing an executor should be inserted thus :—"And I appoint J. B. executor of this my will."

7. Begin, "This is the last will of me, W. B. of S." ; and end, "and I revoke all former wills and codicils." Dated this day of one thousand, etc.

CHAPTER XVI.

MENTAL UNSOUNDNESS.

In the whole range of medical jurisprudence there is no subject more interesting, more difficult, or more important than the diagnosis of insanity, and its relation to the criminal responsibility of individuals. It is impossible, in the short space at our disposal, to do more than to offer a few remarks which may assist the student in the elucidation of some of the most important cases which may engage his attention.

Legal Definitions.—Three forms of mental disorder are recognised in law :—

1. *A nativitate, vel dementia naturalis*—idiocy or natural fatuity.
2. *Dementia accidentalis, vel adventitia*—general insanity, either temporary or permanent, lunacy.
3. *Dementia affectata*, acquired madness from intoxication, etc. (See "Delirium Tremens," p. 229.)

Under the term lunacy are included the mania, monomania, and dementia of medical writers. Another term frequently used in legal proceedings, the meaning of which it is not easy to give, is "*non compos mentis*," *unsoundness of mind*. According to the late Forbes Winslow, "unsoundness of mind is not lunacy" in the legal acceptance of the phrase. This term was first used in a Statute passed in the reign of Henry VIII., relating to the punishment of treasonable offences, and is defined by the early law text-books to be strictly one who *gaudet lucidis intervallis*—a definition not psychologically exact. The phrase "unsoundness of mind" was first used by the late Lord Eldon to designate a state of mind not exactly idiotic, and not lunatic with delusions, but a condition of intellect occupying a place between the two extremes, and unfitting the person

for the government of himself and the management of his affairs.

The above definition has been acted upon by other judges —Lyndhurst, Brougham, etc. As a rule, a medical witness will consult his own interest in not attempting to define insanity, bearing in mind the philosophic caution of Polonius, who, when addressing Hamlet's mother, says—

> Your noble son is mad :
> Mad call I it ; for, to define true madness,
> What is't but to be nothing else but mad ?

To the legal mind, the chief character of insanity is the presence of *delusion ;* but this view is far too restricted. It was first advanced by Erskine in the trial of Hadfield. Before that trial the doctrine was that every man was responsible for his acts, unless he was totally deprived of his understanding and memory, and did not know what he was doing, "no more than an infant, than a brute, or a wild beast" (R. *v.* Arnold). In the case of Bellingham, the knowledge of "right" and "wrong" in the abstract was the test of mental unsoundness ; and, as in the opinion of the judge and jury he was held to be capable of solving this metaphysical problem, Bellingham was duly hanged.

Since the trial and acquittal of MacNaughton on the ground of insanity, the doctrine of the knowledge of abstract right and wrong has been changed to a knowledge of right and wrong in relation to the particular act of which the person is accused, and also at the time of committing it.

It has also been held that, on the assumption that a person labours under partial delusion only, and is not in other respects insane, he must be considered in the same situation as to responsibility as if the facts, with respect to which the delusion exists, were real. For example, if, under the influence of delusion, he supposes another man to be in the act of attempting to take his life, and he kills that man, as he supposes, in self-defence, he would be exempt from punishment. If his delusion was that the deceased had inflicted a serious injury on his character and fortune, and he killed him in revenge for such supposed injury, he would be liable to punishment. "Here," says Maudsley, "is an unhesitating assumption that a man, having an insane delusion, has the power to think and act in

regard to it *reasonably*, . . . that he is, in fact, bound to be reasonable in his unreason, sane in his insanity." Yet this was the doctrine laid down by the judges in answer to certain questions propounded by the House of Lords after the acquittal of MacNaughton (see Maudsley's *Responsibility in Mental Disease*, pp. 88 *et seq.*)

As laid down by English lawyers, madness absolves from all guilt in criminal cases. Where the deprivation of the understanding and memory is total, fixed, and permanent, it excuses all acts; so, likewise, a man labouring under adventitious insanity is, during the frenzy, entitled to the same indulgence, in the same degree, as one whose disorder is fixed and permanent (Beverley's Case, Co. 125, Co. Litt. 247, 1 Hale 31). "But the difficulty in these cases is to distinguish between a total aberration of intellect and a partial or temporary delusion merely, notwithstanding which the patient may be capable of discerning right from wrong; in which case he will be guilty in the eye of the law, and amenable to punishment."[1]

Lord Hale, who first pointed out the distinction to be drawn between total and partial insanity, offered the following as the best test he could suggest:—"Such a person, as labouring under melancholy distempers, hath yet as great understanding as ordinarily a child of fourteen years hath, is such a person as can be guilty of felony." (On this subject, see R. *v.* Ld. Ferrers, 19 St. Tr. 333; R. *v.* Arnold, 16 St. Tr. 764, etc.)

To excuse a man from punishment on the ground of insanity, it appears that it must be distinctly proved that he was not capable of distinguishing right from wrong, and that he did not know, at the time of committing the crime, that the offence was against the laws of *God* and *nature* (R. *v.* Offord, 5 C. & P. 186).

I shall here quote from Macdonald's *Criminal Law of Scotland*:—"Insanity or idiocy exempts from prosecution. But there must be an alienation of reason such as misleads the judgment, so that the person does not know 'the nature of the quality of the act' he is doing, or if he does know it, that he does not know he is doing what is wrong. If there be this alienation, as connected with the act committed, he is not liable to punishment, though his conduct may be otherwise

[1] Archbold's *Criminal Cases*.

rational. For example, if he kill another when under an insane delusion as to the conduct and character of the person—*e.g.* believing that he is about to murder him, or is an evil spirit,—then it matters not that he has a general notion of right and wrong. For, in such a case, 'as well might he be utterly ignorant of the quality of murder.' He does the deed, knowing murder to be wrong, but his delusion makes him believe he is acting in self-defence, or against a spirit. Nor does it alter the effect of the fact of insanity at the time, that the person afterwards recovers. . . . But the alienation of reason must be substantial. Oddness or eccentricity, however marked, or even weakness of mind, will not avail as a defence. Even monomania may be insufficient as a defence, where the delusion and the crime committed have no connection, or where the person, though having delusions, was yet aware that what he did was illegal."

Mere moral insanity—where the intellectual faculties are sound, and the person knows what he is doing, and that he is doing wrong, but has no control over himself, and acts under an uncontrollable impulse—does not render him irresponsible (R. *v.* Burton, 3 F. & F. 772). Some medical writers contend that there are two forms of insanity—moral and intellectual. The law only recognises the latter, owing probably to the difficulty of distinguishing between so-called moral insanity and moral depravity. Taylor says:—"Further, until medical men can produce a clear and well-defined distinction between moral depravity and moral insanity, such a doctrine, employed as it has been for the exculpation of persons charged with crime, should be rejected as inadmissible."

The day may not be far distant when the term "moral depravity" will be unknown, and future generations, ceasing to believe in absurd superstitions, will come to look on crime as the result of disease of the brain, and learn to treat, instead of to punish, the morally diseased. (For a full discussion of this subject, the reader is referred to the works of Dr. Henry Maudsley.)

The fact of the sanity or insanity of the prisoner at the time the crime was committed is left to the jury to decide, guided by the previous and contemporaneous acts of the party; and it has been laid down by Lord Moncreiff in Scotland, and Lord Westbury in England, that the mental soundness or

unsoundness of any individual is to be decided by the jury on the ordinary rules of everyday life, and that on these principles they are as good judges as medical men. The whole tendency of legal practice, when dealing with the plea of insanity, is to entirely ignore the medical evidence. On the question of medical evidence in cases of insanity, Doe J., of New Hampshire, remarks: "At present, precedents require the jury to be instructed by experts in new medical theories, and by judges in old medical theories," and that in this "the legal profession were invading the province of medicine, and attempting to install old exploded medical theories in the place of facts established in the progress of scientific knowledge. If the tests of insanity are matters of law, the practice of allowing experts to testify what they are should be discontinued; if they are matters of fact, the judge should no longer testify without being sworn as a witness, and showing himself qualified to testify as an expert."

Lunacy—What Constitutes? (8 and 9 Vict. c. 100, secs. 90 and 114).—Imbecility and loss of mental power, whether arising from natural decay, or from paralysis, softening of the brain, or other natural cause, and although unaccompanied with frenzy or delusion of any kind, constitute unsoundness of mind, amounting to lunacy within the meaning of 8 and 9 Vict. c. 100 (R. *v.* Shaw, 1 C.C. 145).

The above is the last definition of lunacy up to 1875; but as the law on this subject is so constantly changing, the student will find it best to consult the *Law Reports* from time to time. (See the account in the case of R. *v.* Treadaway, *Law Reports.* Also the *Lancet*, on the same case, vol. i. 1877.)

For some valuable remarks on the subject of the irresponsibility of madmen, the student is referred to the works of Maudsley, Prichard, Ray, Hoffbauer, Georget, and others.

The following suggestions are offered for consideration on this subject:—

1. Was the act an isolated event in the life of the culprit? Has it the appearance of spontaneity, or was it the culminating point of a life spent in so-called criminal acts?

2. Absence of a motive for the committal of the deed.—The absence of an *apparent* motive is no proof of an unsound mind; the moving principle may be "*the conscious impulse to the illegal gratification of a selfish desire.*"

3. The presence or absence of a well-concerted plan of action is a diagnostic sign of little value.—Casper remarks that "only in one case can the examination of the systematic planning of the deed afford any information, and that is when these plans and preparations themselves evince the stamp of a confused intellect, and betray the hazy consciousness, the mental darkness, in which the culprit was involved."

4. A dominant delusion may be so concealed as to be for a time undiscoverable. The case of the man who gave no indication of his madness till he was asked to sign the order for his release, when he signed *Christ*, is an example how carefully a delusion may be concealed even during a most careful examination. Questions directed to this point showed that he laboured under all the errors which such a delusion might suggest.

5. It may "easily be conceived that insane persons, whose unreason affects only one train of thought more or less restricted, yet labour in other respects under disorders of feeling which influence their conduct and their actions and behaviour, without materially affecting their judgment: and that many of such deranged persons, who often conduct themselves tolerably well in a lunatic asylum, and while living among strangers with whom they have no relations, and against whom they have no prejudices or imaginary reason of complaint; subjected, besides, to the rules of the house and to an authority that nobody attempts to dispute; would, nevertheless, if restored to liberty and residing in the midst of their families, become insupportable, irritable at the slightest contradiction, abusive, impatient of the least remark on their conduct, and liable to be provoked by trifles to the most dangerous acts of violence. If, under such circumstances, a lunatic should commit any act of injury or serious damage to another, would it be just to punish him; because it cannot be made apparent that the action has any reference to, or connection with, the principal illusion which is known to cloud his judgment, it being apparent that his moral faculties have undergone a total morbid perversion?"

6. Insanity with lucid intervals.—Haslam, Ray, and others appear to deny the possibility of lucid intervals; but M. Esquirol, on the other hand, fully recognises the existence of this form of insanity. In a legal sense, a temporary cessation

of the insanity constitutes a lucid interval, but the cessation must be complete, and not merely a remission of the symptoms. The interval must be of some duration; and when continuous insanity has been proved, the onus of proving a lucid interval in civil cases rests with the party trying to support the validity of a deed executed during the alleged interval. "If you can establish," says Sir W. Wynne, "that the party afflicted habitually by a malady of the mind has intermissions, and if there was an intermission of the disorder at the time of the act, that being proved is sufficient, and the general habitual insanity will not affect it, but the effect of it is this—it inverts the order of proof and presumption; for, until proof of habitual insanity, the presumption is that the party agent, like all human creatures, was rational; but when an habitual insanity in the mind of the person who does the act is established, then the party who would take advantage of the fact of an interval of reason must prove it." In civil cases the law recognises the validity of wills made during lucid intervals, and has even taken the reasonableness of a will as a proof of a lucid interval.

7. Have measures been taken by the culprit to escape punishment?

The classification adopted here is that given by Ray, and is sufficient for all practical purposes:—

INSANITY.	Defective development of the faculties.	*Idiocy* . .	1. Resulting from congenital defect. 2. Resulting from an obstacle to the development of the faculties supervening in infancy.
		Imbecility .	1. Resulting from congenital defect. 2. Resulting from an obstacle to the development of the faculties supervening in infancy.
	Lesion of the faculties subsequent to their development.	*Mania* . .	1. Intellectual— (*a*) General. (*b*) Partial. 2. Affective— (*a*) General. (*b*) Partial.
		Dementia . .	1. Consecutive to mania, or injuries of the brain. 2. Senile, peculiar to old age.

DEFECTIVE DEVELOPMENT OF THE FACULTIES.

Idiocy. Cretinism. Imbecility.

Idiocy is congenital, and was defined by Esquirol thus:—Idiocy is not a disease, but a condition in which the intellectual faculties are never manifested, or have never been developed sufficiently to enable the idiot to acquire such an amount of knowledge as persons of his own age, and placed in similar circumstances with himself, are capable of receiving. Idiocy commences with life, or at an age which precedes the development of the intellectual and affective faculties, which are from the first what they are doomed to be during the whole period of existence. Since the days of Esquirol, much improvement has been made in the care and treatment of the idiot; and it appears that he is capable of some, though in most cases slight, mental culture. The cases in which improvement takes place probably belong to imbecility, leaving the *idiot* in the same condition as described by Esquirol.

Cretinism differs from idiocy in being endemic; it is also more curable, or at least more susceptible of improvement, than the latter. In the idiot the malady is congenital; the cretin, on the other hand, may to all appearances be free from disease for a time. "Every cretin is an idiot, but every idiot is not a cretin; idiocy is the more comprehensive term, cretinism is a special kind of it." The enlarged thyroid gland, high-arched palate, and brown or yellow colour of the skin, are characteristic of the cretin. Local causes seem to be at work in the production of cretinism; but what the exact nature of these causes is has not been definitely settled. It has been attributed to miasma, to overcrowding in low-lying, badly-ventilated houses, and to ill-assorted marriages. Smallness of the brain, premature ossification of the cranium, and want of symmetry in the brain, have also been mentioned among the causes of cretinism.

The idiot is usually cunning, mischievous, and dirty in his habits.

The derivation of the word idiot, from the Greek, ἰδιώτης—*a private person*, or *an ill-informed ordinary fellow*—is peculiar. A person suffering from any form of mental unsoundness, and thereby rendered incapable of taking care of himself or of his property, was formerly called by English law "an idiot," and

this word was not infrequently joined with "fatuus" in old writs.

Imbecility.—This is a minor form of idiocy, and may or may not be congenital; it also admits of considerable degrees of intensity. Hoffbauer has divided imbecility (*Blödsinn*) into five degrees, and stupidity (*Dummheit*) into three.

Legal Relations of Idiocy and Imbecility.—The legal definition of an idiot is "one who is of non-sane memory from his birth by a perpetual infirmity, without lucid moments." With regard to responsibility or irresponsibility of idiots and imbeciles, much will depend upon the degree of mental weakness present.

MANIA.

Mania is the result of a morbid condition of the brain, and to express which "the term raving madness may be used with propriety, as an English synonym for mania. All maniacs display this symptom occasionally, if not constantly, and in greater or less degrees." Like other diseases, mania observes the same pathological laws. There is a period of incubation, during which the true state of the patient is in most cases misunderstood, or not appreciated. Mental exaltation may exist from the first onset of the disease, or the attack may be ushered in by a stage of gloom or despondency. The general health shows signs of impairment, the liver becoming sluggish, and the bowels confined or relaxed. In some cases a febrile condition of the system is among the premonitory symptoms of an attack of mania. The physical health is not usually much affected during the paroxysm.

Dr. Conolly remarks that "even acute mania is not always accompanied by the ordinary external signs of excitement. It would seem as if we had yet to learn the real symptoms of cerebral irritation. Certainly, in recent cases of mania—cases which have lasted more than six weeks, and in young persons in whom I have seen the maniacal attack pass into dementia —I have known the most acute paroxysms of mania exist, rapid and violent talking, continual motion, inability to recognise surrounding persons and objects, a disposition to tear and destroy clothes and bedding, without any heat of the scalp or of the surface, without either flushing or paleness of the face, with a clean and natural appearance of the tongue, and a pulse no more than eighty or eighty-five."

This may occur in some cases, but in the majority there is always some amount of physical derangement; the system, however, gradually becoming tolerant of the undue excitement to which it is subjected.

Following the classification adopted, Intellectual Mania will now be briefly considered under its two divisions—*General* and *Partial*.

General Intellectual Mania.—By many medical writers general intellectual mania is divided into mania and melancholia. The mind in the former form of the disease is involved in the most chaotic confusion possible, and there is also considerable bodily derangement. The moral faculties become more or less affected, and the patient's social and domestic relations are greatly altered. At one time he is subject to violent fits of immoderate laughter, at another he is gloomy and taciturn; sometimes quiet and tractable, at others wild and excited, necessitating close confinement. He is haunted by wild delusions, which at times take entire possession of him, and under the influence of which he acts in the most extraordinary manner. In the latter—melancholia, or mania with depression—delusion may be absent, or, rather, for a time undetectable. The sufferer is gloomy, and troubled with unhappy thoughts, which sometimes lead him to self-destruction. He is sleepless, and rejects his food as unnecessary. He may be aroused for a short time by questions addressed to him, his replies to which are usually given correctly, most frequently in monosyllables; but the moment his questioner leaves him he relapses into his former gloomy state.

It may be as well to define in this place the difference between *a delusion* and *an illusion*.

A *delusion* is a chimerical thought; an affection of the mind.

An *illusion* is a perversion of the senses; a mockery; false show; counterfeit appearance.

A *delusion* of the mind—an *illusion* of the senses.

Dr. Taylor remarks that "hallucinations are those sensations which are supposed by the patient to be produced by external impressions, although no material objects act upon his senses at the time. Illusions are sensations produced by a false

perception of objects. When the hallucination or illusion is believed to have a positive existence, and this belief is not removed either by reflection or by an appeal to the other senses, the person is insane; but when the false sensation is immediately detected by the judgment, and is not acted on as if it were real, then the person is sane."

Partial Intellectual Mania.—The term *monomania*, first suggested by Esquirol, is now generally given to this variety of insanity. The patient, in the simplest form of this disorder, becomes possessed of some single notion, which is alike contradictory to common sense and to his own experience. Thus, he may fancy himself made of glass; and influenced by this idea, he walks with care, and in dread of being broken by contact with other bodies. In the case of an inmate at the City of London Asylum, the presence of a weasel in the stomach was stated by one woman. Esquirol mentions the case of a woman with hydatids in her womb, who believed that she was pregnant with the devil. Most of these strange fancies appear to be dependent on errors of sensation.

Monomaniacs are ready enough to declare their predominant idea; yet at times, and that without the occurrence of a lucid interval, they will as carefully conceal it. "In the simplest form of monomania, the understanding appears to be, and probably is, perfectly sound on all subjects but those connected with the hallucination. When, however, the disorder is more complicated, involving a longer train of morbid ideas, we have the high authority of Georget for believing that, though the patient may reason on many subjects unconnected with the particular illusion on which the insanity turns, the understanding is more extensively deranged than is generally suspected."

MORAL MANIA.

Pinel first drew attention to this form of madness. Prichard defines it as "consisting in a morbid perversion of the natural feelings, affections, inclinations, temper, habits, and moral dispositions, without any notable lesion of the intellect or knowing and reasoning faculties, and particularly without any maniacal hallucinations."

It is divided into—*General* Moral Mania. *Partial* Moral Mania.

General Moral Mania.—"There are many individuals,"

says Prichard, "living at large, and not entirely separated from society, who are affected in a certain degree with this modification of insanity. They are reputed persons of a singular, wayward, and eccentric character. An attentive observer will often recognise something remarkable in their manners and habits, which may lead him to entertain doubts as to their entire sanity; while circumstances are sometimes discovered on inquiry which add strength to this suspicion. In many instances it has been found that a hereditary tendency to madness has existed in the family, or that several relatives of the person affected have laboured under other diseases of the brain. The individual himself has been discovered to have suffered, in a former period of life, an attack of madness of a decided character. His temper and disposition are found to have undergone a change, or to be not what they were previously to a certain time; he has become an altered man, and the difference has perhaps been noted from the period when he sustained some reverse of fortune which deeply affected him, or the loss of some beloved relative. In other instances, an alteration in the character of the individual has ensued immediately on some severe shock which his bodily constitution has undergone. This has been either a disorder affecting the head, a slight attack of paralysis, or some febrile or inflammatory complaint, which has produced a perceptible change in the habitual state of his constitution. In some cases, the alteration in temper and habits has been gradual and imperceptible; and it seems only to have consisted in an exaltation and increase of peculiarities which were always more or less natural and habitual. Persons labouring under this disorder are capable of reasoning, or supporting an argument upon any subject within their sphere of knowledge that may be presented to them; and they often display great ingenuity in giving reasons for the eccentricities of their conduct, and in accounting for, and justifying, the state of moral feeling under which they appear to exist. In one sense, indeed, their intellectual faculties may be termed unsound: they think and act under the influence of strongly excited feelings; and persons accounted sane are, under such circumstances, proverbially liable to error, both in judgment and conduct." (For interesting cases of this form of madness, see Ray's *Jurisprudence of Insanity*.)

Partial Moral Mania.—In the case of the unfortunate sufferers from this malady, one or two only of the moral powers are perverted.

This division admits of several subdivisions :—

Kleptomania.—A marked propensity to theft. "There are persons," says Rush, "who are moral to the highest degree as to certain duties, but who, nevertheless, lie under the influence of some vice. In one instance, a woman was exemplary in her obedience to every command of the moral law except one—she could not refrain from stealing. What made this vice more remarkable was, that she was in easy circumstances, and not addicted to extravagance in anything. Such was the propensity to this vice, that when she could lay her hands on nothing more valuable, she would often, at the table of a friend, fill her pockets secretly with bread. She both confessed and lamented her crime."

Pyromania.—This consists in an insane impulse to set fire to everything—houses, churches, and property of every kind and description.

Erotomania and Nymphomania.—This is known as amorous madness, and consists in an inordinate and uncontrollable desire for sexual intercourse. The unfortunate victims of this disease often express the greatest disgust and repugnance for their conduct.

Homicidal Mania.—In this form of madness the propensity to homicide is very great, and in most cases uncontrollable. In the case of the notorious Deeming, hanged in Australia in 1892 for the murder of his wife, an appeal was made from the finding of the Colonial Court by which he was tried to the Privy Council, on the ground of his being affected with homicidal mania. The plea was not sustained. (See the case of Henrietta Cornier, given by Prichard, Ray, and others.)

The following suggestions may be of assistance in forming a diagnosis as to the existence or non-existence of this form of madness :—

1. Previous history of the individual.—*Melancholy, eccentric, morose, etc.*

2. Absence of motive.—*Gain, jealousy, revenge, hatred, etc.*

3. A number of victims are often sacrificed at one time. — *The murderer, on the other hand, seldom sheds more blood than is necessary for his success.*

4. Proceedings of the murderer before and after the crime.—*Absence of attempts at concealment or escape on the part of the madman.*

5. Character of the victims.—*Not infrequently, in the case of madmen, their victims are those whom, when sane, they loved most, and to whom they were most attached.*

Suicidal Monomania, or the Propensity to Suicide.—Much discussion has arisen on this subject. Suicide is not always the result of unsoundness of mind. Some, like M. Esquirol, are inclined to consider suicide as always a manifestation of insanity. In the present day, the dislike of coroners' juries to bring in any other verdict but that of "suicide whilst in a state of unsound mind" is proverbial.

DEMENTIA OR FATUITY.

Dementia consists in a failure of the mental faculties, not congenital, but coming on during life. "A man," says Esquirol, "in a state of dementia is deprived of advantages which he formerly enjoyed. He was a rich man who has become poor. The idiot, on the contrary, has always been in a state of want and misery." In this state there is always more or less incoherence, and maniacal paroxysms are not infrequent. In mania, incoherence may be present, but then it is characterised by sustained and violent excitement. In dementia, on the other hand, there is apparent torpor and exhaustion of the mental faculties. Closely allied to this form of mental unsoundness is that interesting disease known as "general paralysis of the insane," or perhaps a better term, *progressive paralysis of the insane.* It is considered by some to precede the psychical derangement, a contrary opinion being held by others. General paralysis may accompany any of the forms of mental derangement, but it is generally preceded by a stage of melancholy. As the paralytic affection becomes more marked, there is a concurrent loss of memory and incapability of mental association, and all sense of duty is lost; the patient becomes careless as to his person, and dirty in his habits. He expresses himself as possessed of great property, and boasts of the wonderful deeds that he can or has accomplished. Gradually he sinks into a state of complete mental and physical decay. He cannot give expression to his thoughts, and has to be fed, the food being pushed into his mouth. The symptom which first attracts the attention, and which is perhaps the

first in order of sequence, is a modification in the articulation. "This is neither stammering nor hesitation of speech. It more closely resembles the thickness of speech observable in a drunken man. It depends upon loss of power over the co-ordinate action of the muscles of vocal articulation." If the tongue be now examined, it will be found that when it is protruded it is not inclined to one side, but that it is tremulous, and is protruded and withdrawn in a convulsive manner. Griesinger was the first to call attention to the fact, and his statement has since been confirmed, "that this motory disorder is at the commencement not so much paralytic as convulsive in its nature." The gait becomes unsteady, the patient walks stiffly, and stumbles over the slightest unevenness in the floor. Step by step the paralysis progresses, till at last the unfortunate sufferer takes to his bed, on which he may lie for months. Sometimes, especially during the earlier stages, he may suffer from terrible delusions, from maniacal paroxysms, or from epileptic fits, the latter possessing certain peculiarities. The tongue during the fit is seldom bitten, which is so commonly the case in epilepsy; and the convulsions are not so general, being limited more to one side than to the other. It is also remarkable that each fit is in most cases followed by an increase of the mental derangement.

Prichard recognises four stages of dementia or fatuity:—

First Stage.—Forgetfulness and impaired memory. This is common to old age. In most cases, passing events produce little, if any, impression, whilst the past is remembered with tolerable freshness.

Second Stage.—Incoherence and unreason, characterised by a total loss of the reasoning faculty.

Third Stage.—Incomprehension. The person so affected is quite incapable of comprehending the meaning of the simplest question; and should he attempt to reply, his answer is generally remote from the subject.

Fourth Stage.—Inappetency. The animal instincts are lost. The unfortunate sufferer lives, and that is all, being scarcely conscious of life. Organic life is all that is left.

DELIRIUM TREMENS. SIMPLE DELIRIUM. SOMNAMBULISM. SLEEP-DRUNKENNESS.

Delirium Tremens.—A temporary form of insanity, the result of excessive indulgence in spirituous liquors. The drunkard, under the effects of intoxication, "can derive no

privilege from a madness voluntarily contracted, but is answerable to the law equally as if he had been in full possession of his faculties at the time" (1 Hale 32; Co. Litt. 247). The intoxication of the defendant may be taken as a mitigating circumstance, showing that the deed was unpremeditated. A person rendered incapable of using his reason by intoxication brought about by others, is not liable for his actions.

Simple Delirium.—Acts performed during attacks of certain diseases—fever, sunstroke, etc.—accompanied with delirium, do not render the individual liable to punishment; and wills made during the continuance of the disorder, if they contain no statement inconsistent with the known wishes and desires of the party during health, are valid, the law looking more to the good sense of the will as a proof of a lucid interval, than to the proved existence of such lucid interval.

Somnambulism, etc.—This is an abnormal mental state, closely allied to that artificially produced and known under the names of mesmerism, hypnotism, electro-biology, etc. It is commonly known as "sleep-walking." In this condition the mind appears to become enslaved by one train of ideas to the exclusion of all others; the somnambulist, thus deeply bent on the accomplishment of a definite end, takes no heed of those objects which are in no way connected with the dominant ideas in his mind. Hence, he walks safely past dangers which, when awake, would disconcert his judgment and weaken his will. Somnambulism appears also to be closely connected with epilepsy. In 1878, a man named Fraser was tried in Glasgow for the murder of his child by beating it against the wall. He was acquitted on the ground of being unconscious of the nature of his act by reason of somnambulism. He was sprung from an epileptic and insane stock; his mother died in an epileptic fit, and some of his other relatives were insane. Thus it appears, if the somnambulism be proved, the accused is exonerated from any responsibility connected with the act for which he is being tried. So also, if a person be suddenly aroused from a deep sleep—*somnolentia* or *sleep-drunkenness*,—the question may be raised as to his responsibility for an act committed at the moment of awakening (R. *v.* Milligan). There cannot be a doubt but that if a person be suddenly aroused whilst dreaming, he may unconsciously commit acts, the outcome of his dream, which, unless the possibility of this

condition be recognised, may entail severe punishment on him. This state is closely allied to that mental condition which sometimes occurs in epileptics immediately after a fit. But in this, as in cases of somnambulism, the facts of the case would have to be most carefully scrutinised.

The following hints may be of use as a guide in determining the responsibility or not of the accused :—

1. The person must be shown to have a general tendency to deep and heavy sleep, out of which he can only be aroused by a violent and convulsive effort.

2. Are there any circumstances which, happening before the individual went to sleep, would produce a train of disturbed thought not entirely composed by sleep ?

3. Did the act occur during the usual hours for sleep ?

4. Was the cause of the awakening sudden, and does the act bear throughout the character of unconsciousness ?

5. What were the subsequent acts of the accused in relation to the deed ? Did he try to evade responsibility ? This must not have too much stress laid upon it, for the wretchedness of the sudden discovery may so overcome him, that he may seek to shelter himself from the consequences of an act for which he is legally but not morally responsible.

DIRECTIONS FOR SIGNING MEDICAL CERTIFICATES FOR THE RESTRAINT OF THE INSANE.

(*a*) In the case of pauper patients the signature of one medical man is alone required, but the order must be signed by a Justice of the Peace, or by the officiating clergyman and the relieving officer of the parish in which the lunatic for the time being resides. In cases of great emergency, a person, if not a pauper, may be received into an asylum or hospital upon a certificate signed by *one* medical practitioner, provided that within *three days* the proper certificates be duly signed and delivered. To retain a person beyond the three days renders the keeper of the asylum liable to an action for misdemeanour.

(*b*) In all other cases—

1. The signatures of two medical men are required. Any one signing the certificate unless duly qualified is liable to a prosecution for misdemeanour (R. *v.* Ogilvy).

2. A relation or friend must also sign the order of admission into the asylum.

3. The medical men must not be in partnership, as principal and assistant, or have any direct or indirect interest in the patient or in his keeping (16 and 17 Vict. c. 96, sec. 4).

4. They must make separate visits, and at different times.

5. Each must write clearly in the proper place, on the form prescribed by law—(1) The facts observed by himself as evidence of insanity. (2) The facts observed by others as evidence of insanity. The name of his informer *must* be given.

6. The correct address of the patient and the date of the visit must be stated. The addresses of the certifying medical men must also be stated.

7. The certificate need not be filled up, signed, and dated on the day of examination of the patient, but the examination must take place within seven clear days of the admission of the patient into an asylum. Neglect of this rule invalidates the certificate (Hall *v.* Semple). The certificate remains valid for seven days; after the lapse of that time, before admission to an asylum can be obtained, new certificates must be procured.

8. Great care must be taken to follow carefully the marginal directions on the certificate form. The most trivial omission will invalidate the certificate, and in the case of Greenwood, the omission of the name of the street and the number of the house was held sufficient to set it aside. A medical man should remember that, although his certificate may have passed the scrutiny of the Commissioners, it is liable to be made the subject of discussion in a court of law, and in cross-examination he will have to support the statements therein made. According to Dr. Millar, of Bethnal House Asylum, very few of the medical certificates of insanity are properly filled up. I therefore copy the certificate, properly filled up by himself, and given in his little book on *Hints on Insanity.*

MEDICAL CERTIFICATE PROPERLY FILLED UP.

1. *Here set forth the qualification entitling the person certifying to practise as a* physician, surgeon, *or* apothecary.	I, the undersigned, *John Millar,* being a (1) *Licentiate of the Royal College of Physicians, Edinburgh,*
2. Physician, surgeon, *or* apothecary, *as the case may be.*	and being in actual practice as a (2) *Physician,* hereby certify that I, on the *third* day of *November, One thousand eight hundred and*
3. *Here insert the street and number of the house (if any), or other like particular.*	*eighty-eight,* at (3) 600 *Cambridge Road, Bethnal Green,* in the county of *Middlesex,* separately from any other medical practitioner, personally examined *James Thompson, sen.,* of
4. *Insert residence, and profession or occupation (if any).*	(4) 600 *Cambridge Road, Bethnal Green, gentleman,* and that the said *James Thompson, sen.,*
5. Lunatic, *or* an idiot, *or* a person of unsound mind.	is a person (5) *of unsound mind,* and a proper person to be taken charge of, and detained under care and treatment; and that I have formed this opinion upon the following grounds, viz.:—
6. *Here state the facts.*	1. Facts indicating insanity observed by myself (6)— *He is incoherent in his conversation, violent in his conduct, and quite unable to take care of himself.*
7. *Here state the information, and from whom.*	2. Other facts (if any) indicating insanity communicated to me by others (7)— *His son, James Thompson, jun., informs me that he has threatened to commit suicide, and has twice attempted it with a razor.*

(Signed) Name—*JOHN MILLAR.*

Place of abode—*Bethnal House, Bethnal Green.*

Dated this *third* day of *November, One thousand eight hundred and eighty-eight.*

TABLE RELATING TO "FACTS" OF INSANITY, COMPILED FROM MILLAR.

Facts offering no Evidence of Insanity.	Vague and Irrelevant Facts.	Good Facts.
1. Refuses to take her medicine and resists in every way; closes her teeth; threatens to strike every one near her; obliged to use the strait-waistcoat.	1. She is suspicious of her husband; says he keeps bad company; she is most irritable and jealous, and takes stimulating drinks to a dangerous and exciting extent.	1. She states that she is a lost person and without hope of forgiveness; that she will be taken to prison, and die a miserable death; that the devil whispers in her ear that she has committed the unpardonable sin.
2. Violent in her temper, and very abusive.	2. Obstinate; has the manner and appearance of an insane person; complained of her head; refused her food, and would not go downstairs; melancholy.	2. Great taciturnity: complete seclusion from society; aversion to cleanliness; wandering about the streets at improper hours.
3. Moody and irritable temperament, and of weak memory in many particulars.	3. He has imperfect sight: good hearing and taste; he is unable to speak; his gait is ape-like, and the skull-bones seem to have fallen together from the want of cerebral development. He will occasionally slap his face and strike his hands; sometimes makes a howling noise.	3. He states that he is a Prince of France; that he possesses a palace, and has recently had two fortunes left him (he cannot tell by whom)—one of £400,000, the other of £600,000: that he is going to Liverpool, a distance of 150 miles, with a horse and cart, which will take him four hours to go, and eight to return.
4. General restlessness of manner; considers himself heavily involved in debt to many thousand pounds; says he has been ruined by the Government, and that he intends prosecuting the Admiralty for £5000 damages.	4. She is very good-tempered; but day and night she talks almost incessantly; occasionally sings. She says she comes from Otaheite, and relates stories of those around her doing absurd things.	4. Inability to hold any rational conversation; her manner and conduct are totally at variance with her usual habits.

The following are examples of "Facts" sent back to be amended by the Commissioners—the emendations in italics :—

1. Incoherence, perversion of facts, delusion. *Fancies that he possesses large amounts of money which people have secreted from him.*

2. Says her sister lives in Chiselhurst, and she fears she is dying. She took great notice of my feet, and remarked that they were very large. Query by Commissioner—Are these delusions? *Her sister does not live at Chiselhurst, and is perfectly well; my feet are not large.*

3. General restlessness of manner; considers himself heavily involved in debt to many thousands of pounds, *whereas his debts do not amount to a few hundreds;* says he has been ruined by the Government, *whereas he has only been dismissed from his appointment on account of his incapacity;* and he intends prosecuting the Admiralty for £5000 damages, *he having no real ground of action.* (This was twice sent back for correction, the first correction being—*By these statements I was satisfied that the patient was of unsound mind, and by his general conduct during examination.* Finally amended as given above.)

LIABILITIES OF PERSONS SIGNING LUNACY CERTIFICATES AND RECEIVING INSANE PATIENTS.

In the case of Nottidge *v.* Ripley and Nottidge, the Lord Chief Baron having been understood to intimate an opinion that no person ought to be so confined unless he is dangerous to himself or others, the Commissioners pointed out that the scope of the Lunacy Acts is not thus limited. They said :

"The object of these Acts is not, as your Lordship is aware, so much to confine lunatics, as to restore to a healthy state of mind such of them as are curable, and to afford comfort and protection to the rest. Moreover, the difficulty of ascertaining whether one who is insane be dangerous or not is exceedingly great, and in some cases can only be determined after minute observation for a considerable time.

"It is of vital importance that no mistake or misconception should exist, and that every medical man who may be applied to for advice on the subject of lunacy, and every relative and friend of any lunatic, as well as every magistrate and parish officer (each of whom may be called upon to act in cases of this sort), should know and be well assured that, according to law, any person of unsound mind, whether he be pronounced dangerous or not, may legally and properly be placed in a county asylum, lunatic hospital, or licensed house, on the authority of the preliminary order and certificates prescribed by the Acts.

"Upon the whole, it appears that the power to restrain

and confine a lunatic is limited at common law to cases in which it would be dangerous, either as regards others or himself, for the lunatic to be at large; but that the power to place and detain a lunatic in a registered hospital or licensed or other house, under an order and medical certificates duly made and obtained in accordance with the Lunacy Acts, is not so limited."

LIABILITIES OF PERSONS RECEIVING PATIENTS.

According to the Statute (see 8 and 9 Vict. c. 100, sec. 44), no person is allowed to receive more than one lunatic patient into his house, unless the house be licensed as an asylum; and the Statute further enacts that no person, unless he derive no profit from the care of the patient, or a committee appointed by the Lord Chancellor, shall board or lodge any *one* patient in any house without the proper order and medical certificates. A license for a house becomes necessary only where more than *one* patient is received.

It is also important to remember that if any one receive a person not insane at the time, but who subsequently becomes insane, he renders himself liable to prosecution, unless he procure the necessary medical certificates and order (R. *v.* Wilkins).

Is a Lunatic a competent Witness?—Mr. Fitzjames Stephen maintains (*Criminal Law*) that madmen are competent witnesses in relation to testimony as in relation to crime. If they understand the nature of an oath, and the character of the proceedings in which they are engaged, they are competent witnesses whatever be the nature or degree of their mental disorder. An idiot shall not be allowed to give evidence (Co. Litt. 6 b; Gilb. Ev. 144); a lunatic during a lucid interval may (*Id. Com. Dig. Testm.* [A]). When a lunatic is tendered as a witness, it is for the judge to examine and ascertain whether he is of competent understanding to give evidence, and is aware of the nature and obligation of an oath; if satisfied that he is, the judge should allow him to be sworn and examined (R. *v.* Hill, 2 Den. 255; 20 L.J. [M.C.] 222).

The Civil Rights of Lunatics.—If an individual be suffering from such mental disease as to render him incompetent to manage his own affairs, the law steps in to protect him and his property from injury. But the power so used does not necessarily imply that he is deprived of his personal freedom, but merely such restraint as is necessary for his protection.

Many lunatics, under the protection of the Court, live in their own houses with large establishments. A person so protected by the law is said to be subject to an "interdiction." In these cases a commission is usually granted by the Court of Chancery, and a writ known under the name of "*de lunatico inquirendo*" issued, after certain legal matters of detail are settled, and affidavits from medical men certifying to the insanity of the party have been filed.

The tests of insanity in these cases differ from those required in criminal cases, where the knowledge of right from wrong is imperatively demanded. The mental defect must not be the result of ignorance or want of education, and at one time commissions were only issued when it was shown that lunacy and idiocy alone existed, imbecility or mere weakness of mind not being deemed sufficient to deprive a man of his civil rights, or to place him under the protection of the Court.

To so great an absurdity did this lead, that the man suffering from a delusion sufficient to be comprehended under the legal term "lunacy" was protected, whereas the feeble-minded were left without interference, though needing it more. The cost of these commissions sometimes reached almost fabulous sums. The expense has been somewhat lessened by recent enactments, and the process simplified—the Lord Chancellor having it in his power to direct an inquiry before two Commissioners, thus dispensing with a jury. (See the 16 and 17 Vict. c. 70, and 25 and 26 Vict. c. 86.)

In Scotland, however, the law is far more simple. The cognition proceeds on a *brieve* or writ addressed to the Lord President of the Court of Session, and directs him to inquire "whether the person sought to be cognosced is insane, who is his nearest agnate, and whether such agnate is of lawful age." "And such person shall be deemed insane if he be furious or fatuous, or labours under such unsoundness of mind as to render him incapable of managing his affairs." "The trial is before a judge of the Supreme Court and a special jury. If the insanity be proved, the nearest agnate—relation by the father's side—is by law entitled to the guardianship." No one not a near relative can institute these proceedings.

In Scotland also, the trial by jury may be avoided by applying by petition to the Court of Session for the appointment of a judicial factor or *curator bonis*. Of this appointment

the alleged lunatic is informed, which, if he please, he may oppose; medical evidence is received, and on this the Court rests its decision—the usual course being to remit the case to some competent person to make inquiry, take evidence, and report. The Commissioner is usually the Sheriff.

Examination of the Insane.—A few words of caution need here be said. Medical men will consult their own dignity and that of their profession by remembering that in cases of alleged insanity, as in fact in all other cases when their opinion is sought, they are not justified in taking sides. Their evidence will be the more valuable in proportion to the care they take in examining into the facts of the case, and the good sense and judgment shown in their examination of the patient. To distinguish between the mistakes, the result of ignorance and want of education, and those the result of a feeble mind, is of primary importance. It is no sign of insanity in an uneducated farmer that he knows not the *pons asinorum.* All cases should be tested by considering the surroundings and possible degree of culture of a person placed under like conditions as the party under examination. Has he shown himself capable of an average amount of culture? or is his mental condition inferior to what one might legitimately expect under the influences to which he has been subjected? The medical examiner should also direct his attention to this important point, setting aside all legal and medical theories of insanity, viz.—"Is the case of *such mental disorder* as to create *an incapacity for managing affairs.*"

DUTIES OF A MEDICAL OFFICER TO A UNION WITH REGARD TO LUNATICS.

Every medical officer of a Union district, on his becoming aware that any pauper resident in his district is, or is deemed to be, a lunatic and proper person to be sent to an asylum, must within three days give notice in writing to the relieving officer, or failing him, to the overseers, subject to a penalty not exceeding £10 for neglect. A medical officer, paid to visit a lunatic in his district, renders himself liable to a fine, if, for the sake of retaining the fee, he do not send such lunatic to an asylum when necessary.

SECTION II.

TOXICOLOGY.

CHAPTER I.

DEFINITION OF A POISON—SALE OF POISONS—CLASSIFICATION OF POISONS—ACTION OF POISONS—GENERAL EVIDENCE OF POISONING—GENERAL TREATMENT IN CASES OF POISONING—GENERAL METHODS OF EXAMINATION FOR POISON.

TOXICOLOGY is that division of Forensic Medicine which takes into consideration the modes and actions of poisons upon the living body, the treatment of their effects upon the body, and the methods of detecting them when occasion requires.

Definition of a poison: Neither the law nor medicine defines a poison. The popular definition is to be avoided, viz. that a poison is a substance capable of acting injuriously on the body when taken or administered in a small dose.

Husband defines a poison as "*any substance which, introduced into the system or applied to the body, is injurious to health and destroys life, irrespective of temperature or mechanical means.*"

Taylor and Stevenson define a poison as "*a substance which when absorbed into the blood is, by its direct action, capable of seriously affecting health or destroying life.*"

There are substances, however, which do not require absorption into the blood in order to exert their deleterious action, *e.g.* the corrosive acids and alkalies.

Winter Blyth considers that "*a substance of definite chemical composition, whether mineral or organic, may be called a poison if it is capable of being taken into any living organism, and*

causes, by its own inherent chemical nature, impairment or destruction of function."

According to Luff a poison is "*a substance which, either by its direct action upon the skin or mucous membranes, or after its absorption into the blood, is capable of injuriously affecting health or destroying life.*"

Letheby defines a poison as "*anything which otherwise than by the agency of heat or electricity is capable of destroying life, either by chemical action on the tissues of the living body, or by physiological action from absorption into the system.*"

The law does not recognise the manner in which the substance acts, nor the result; the legal standpoint is the *intent* of the administrator qua administrator. The law is as follows:—"*Whosoever shall administer or cause to be administered or taken by any person any poison or other destructive thing with intent to commit murder shall be guilty of a felony*" (24 and 25 Vict. c. 100, sec. 11).

Section 22. "*Whosoever shall unlawfully apply or administer to or cause to be taken by, or attempt to apply or administer to, or attempt to cause to be administered to or taken by, any person, any chloroform, laudanum, or other stupefying or overpowering drug, matter, or thing, with intent, in any of such cases, thereby to enable himself or any other person to commit, or with intent, etc., to assist any other person in committing any indictable offence, shall be guilty of felony.*"

Section 23 enacts that, "*Whosoever shall unlawfully administer to, or cause to be administered to, or taken by any other person, any poison or other destructive or noxious thing so as thereby to endanger the life of such person, or so as thereby to inflict upon such person any grievous bodily harm, shall be guilty of a felony.*"

Section 24. "*Whosoever shall unlawfully or maliciously administer to or cause to be administered to or taken by any other person any poison or other destructive or noxious thing with intent to injure or aggrieve or annoy such person shall be guilty of a misdemeanour.*"

Section 25. "*If upon the trial of any person charged with the felony above mentioned, the jury shall not be satisfied that such person is guilty thereof, but shall be satisfied that he is guilty of the misdemeanour above mentioned, then, and in every such case, the jury may acquit the accused for such felony and find him guilty of a misdemeanour.*"

Administration of Noxious Drugs.—The law throws on the medical witness the responsibility of the definition of a *noxious thing*, and whether it was given in excess, or liable to cause annoyance or injury to health. At a Bodmin Assize, Lord Chief Justice Cockburn, after consultation with Mr. Justice Hawkins, delivered an important judgment on the subject. A man was charged with having administered cantharides with criminal intent. The Judges ruled that there must not only be an administration of a noxious drug with a guilty intent, but the drug must have been administered in such quantities as to be noxious, whereas the dose here given was too small to be seriously deleterious. Distinction was drawn between a drug like cantharides, which is only noxious when given in excess, and strychnine, a well-established poison. Acquittal was therefore directed. In the case of R. *v.* Cramp, the prisoner was charged with having administered half an ounce of oil of juniper with intent to procure abortion. He was convicted, but appealed on the legal ground that the substance must be noxious in itself, and not only when given in excess. Lord Coleridge ruled that "if a person administers with intent to produce miscarriage something which *as administered* is 'noxious,' he administers a 'noxious thing.'"

The Sale of Poisons.—The law restricts the sale of poisons to pharmaceutical chemists, chemists and druggists, and registered medical practitioners. Poisons according to law are divided into two groups. In Part I. are included arsenic and its preparations; aconite and its preparations; all poisonous vegetable alkaloids and their salts; atropine and its preparations; cantharides; corrosive sublimate; cyanide of potassium and all metallic cyanides and their preparations; emetic tartar; ergot of rye and its preparations; prussic acid and its preparations; savin and its oil; strychnine and its preparations; vermin-killers which contain any of the poisons named in this section.

Part II. includes essential oil of almonds, unless deprived of prussic acid; belladonna and its preparations; tincture of cantharides and all vesicating liquid preparations of cantharides; chloroform; chloral hydrate and its preparations; morphia and its preparations; corrosive sublimate and its preparations; nux vomica and its preparations; opium and its preparations, and preparations of poppies, oxalic acid, red precipitate (red oxide of mercury), white precipitate (ammoniated mercury); vermin-killers, the poisons of which are not included in Part I.

With those in Part I. a registration of the sale is compulsory, the purchaser must be known to or introduced by some person known to the vendor, and the purpose for which the poison is required, the date, the name and amount of the poison sold, the name and address of the buyer, and the entry must be signed by the purchaser and introducer. All substances in Parts I. and II. must be labelled by the vendor with a label bearing the name of the poison, the name and address of the seller, and the word "Poison"; but with those in Part II. no registration as in Part I. is required. In the sale of arsenic both the seller and purchaser must sign the entry, and the introducer must witness it. No arsenic can be legally sold to a person under the age of twenty-one years; nor may it be sold in quantities of less than 10 lbs. unless mixed with soot or indigo—one ounce of the former, or half an ounce of the latter, to each pound of arsenic. If quantities of over 10 lbs. be sold, and the soot or indigo would render it unfit for use in the way desired, then they may be omitted.

Classification of Poisons.—A good and scientific classification of poisons is still wanted. The following may be taken as guides by the student:—

1. INORGANIC.

Corrosive—Sulphuric Acid.
Irritant—Arsenic, etc.

2. ORGANIC.

Irritant—Savin, Cantharides.
Affecting Brain—Opium.
Affecting Spinal Cord—Strychnia.
Affecting Heart—Digitalis.
Affecting Lungs—Carbonic Acid. (GUY.)

IRRITANTS.

Mineral { Acid poisons—Sulphuric Acid.
Alkaline poisons—Caustic Soda.
Non-metallic—Phosphorus, Iodine.
Metallic—Arsenic, Antimony.
Vegetable—Savin, Elaterium, etc.
Animal—Cantharides.

NEUROTICS.

Cerebral—Opium, Hydrocyanic Acid, Alcohol.
Spinal—Strychnia, Nux Vomica.
Cerebro-spinal—Conia, Belladonna, Aconite.
Cerebro-cardiac—Calabar bean, Digitalis. (TAYLOR.)

The subjoined classification is based upon that adopted by the late Professor Sir Douglas Maclagan. Where the poison acts in such a manner as to place it in two or more groups, I have fully described it in one, merely drawing attention to it under the others :—

DIVISION I.

CHEMICAL.

Corrosive,	Acids. Alkalies. Caustic Salts.
Vulnerant,	Glass, Needles.

DIVISION II.

VITAL.

Irritant,	Metalloid,	Phosphorus, Iodine.
,,	Metallic,	Arsenic, Antimony, Mercury, etc.
,,	Vegetable,	Gamboge, Elaterium, Colchicum, Squill.
,,	Animal,	Cantharides, Ptomaines.
Narcotic,	Somniferous,	Opium.
,,	Deliriant,	Hyoscyamus, Belladonna.
,,	Inebriant,	Alcohol, Cocculus Indicus, Chloroform, Ether, Cannabis Indica.
Sedative,	Cardiac,	Digitalis, Aconite, etc.
,,	Cerebral,	Ether, Chloroform, Hydrocyanic Acid.
,,	Neural,	Conium, Aconite.
Excitomotory,		Strychnia, Ergot.
Irrespirable Gases,		Carbonic Acid, Carbon Monoxide, Coal Gas, Chlorine.
Toxicohæmic or Septic,		Snake Venom, Ptomaines, "Toxins."

Action of Poisons.—Amid the difficulties which surround this subject, three points appear to have been clearly made out:—(1) That it is necessary for all poisons to enter the blood before their specific action can be produced. (2) That poisons possess an elective affinity for certain tissues and organs. Thus, arsenic, however introduced into the system, as a rule attacks the stomach; and this peculiarity of action closely allies it to the poisons of typhoid, scarlet fever, smallpox, etc., which appear to have, respectively, an elective affinity for the glands of the intestines, the throat, and the skin. (3) That the habitual use of a poison in medicinal doses does not ensure a perfect toleration on the part of the system with regard to the action of the poison, for that sooner or later a complete

cachexia is produced, showing that the poisonous effect of the drug is not arrested.

Besides the above, there are also certain conditions connected with the action of poisons:—(1) The poison is absorbed and distributed by the blood. (2) A portion is eliminated by the fluid secretions and excretions. (3) Another portion is for a time deposited in the tissues and organs of the body. These processes are of necessity simultaneous.

The channels of entrance and exit are as follow:—Of entrance we have—(1) *The blood-vessels as a result of wounds*—more important in a physiological than a medico-legal question. (2) *The skin and cellular membrane.*—Absorption by the skin is modified by the condition of the part, and also by the form in which the drug is applied. Thus the skin of the arm-pits and groins is more absorbent than the palms of the hands. Watery solutions are not so effective as oily preparations, and the application of the drug in fine powder is more effectual than a watery solution of it. This is explained by the presence of a natural oily, unctuous substance on the skin, which prevents the direct contact of the watery solution, but if the solution be allowed to evaporate on the part, the substance thus left in minute division is then readily absorbed. The danger of allowing strong solutions of corrosive sublimate to evaporate on the head in the treatment of certain skin eruptions is thus explained. (3) *The lungs and air passages.*—Absorption by these organs is most active, hence the intense rapidity in the action of aërial poisons. (4) *The stomach and intestines.*—Poisons introduced into the stomach or intestines take longer to arrive at the special organs on which they act than by the other channels of entrance. They are absorbed by the capillaries and mesenteric veins, and before passing to the heart, by which they enter the general circulation, they pass through the liver, where they are in part excreted in the bile or deposited in the gland. The absorbing power of the stomach is modified by its fulness or emptiness, and poisons not soluble in water may be rendered so by the gastric secretion. Some poisons which act rapidly when entering by a wound, are inert when taken into the stomach. This, though true in some cases, does not always occur; and the inertness of these poisons, it has been suggested, may be due to the elimination of them being as rapid as their absorption, so that a poisonous dose

never enters the circulation. The intestines absorb more rapidly than the stomach, and this must be borne in mind when administering powerful drugs *per anum.*

Of the channels of exit we have :—(1) *The kidneys.* (2) *The lungs.* (3) *The bile.* (4) *The milk.* (5) *The saliva.* (6) *Mucous membrane.* (7) *The skin.*

We know not the cause, but certain poisons appear to select a particular route for their exit—thus iodide of potassium leaves by the urine; mercury and its salts by the saliva; arsenic and eserine, the active principle of the Calabar bean, in small quantities, by the stomach, etc. We are, however, prepared to show that all poisons must enter the blood before they produce their effects, and that almost simultaneously with the entrance of the poison into the blood a process of elimination begins, and that fatal effects depend upon absorption taking place more rapidly than elimination. On the amount also of the poison absorbed do its fatal effects depend, and not on the quantity actually taken. Whilst absorption and elimination are both going on, some of the poison is being deposited in the organs and tissues of the body. As proofs of these statements it has been shown that poisons have been detected in the blood, and that urine, saliva, and milk, fluids secreted from it, may contain portions of the poison taken, and produce dangerous symptoms when given to other animals. Poisons applied to the brain tissue, or to nerve trunks, do not produce symptoms, and the action of a poison may be arrested for a time by compressing by a ligature the main vessels of the limb under the skin of which the poison has been injected. After death no trace of the poison may be detected, the quantity taken being just sufficient to produce a fatal result, or elimination may be so rapid that, although death was directly due to the poison, any remains of its existence cannot be made out. This occurred in the case of Dr. Alexander, who died from an accidental dose of arsenic, all the arsenic being eliminated in *seventeen* days—in another fatal case, in *seven* days (TAYLOR).

As evidence of the diffusion of poisons the following Table may be of use :—

PHYSIOLOGICAL.	Dilatation of the pupil in poisoning by belladonna, hyoscyamus, etc. Contraction of the pupil in poisoning by opium, Calabar bean.

PHYSICAL.	*Taste*—Bitter taste to the secretions. Strychnia, picrotoxia. The milk of animals fed on wormwood may become bitter ; on colchicum, poisonous. *Smell.*—Prussic acid, tobacco, conia, etc. *Colour.*—Skin blackened by nitrate of silver, given internally.

N.B.—By the aid of the spectroscope the salts of lithium and thallium have been detected in the liver and other tissues.

Recapitulation of the Mode of Action of Poisons, and the Causes which Modify their Action.

MODE OF ACTION.

I. LOCAL.

1. Corrosion of the part to which the poison is applied.	Strong acid, alkali, etc.
2. Inflammation as the result of irritants applied to a part.	Arsenic, cantharides, etc.
3. Effects on the nerves of motion and sensation.	Dilatation of the pupil by belladonna, by tingling of the tongue and skin by aconite, paralysis by conia.

II. REMOTE.

1. Common—not to be distinguished from the effects of injury or disease.
2. Specific—peculiar to the poison itself.
   (1) General—affecting the whole system.—Antimony.
   (2) Partial—acting on a particular organ.—Antimony.

MODIFYING CAUSES.

1. Quantity.	1. Quantity of the poison increases its rapidly fatal action. 2. Action changed by the size of the dose. Thus, oxalic acid in large doses acts as a corrosive ; in small doses on the heart, brain, or spinal cord.

2. Form.
- *Solubility* increases the activity of poisons.
- *Chemical Combinations.*—Baryta is poisonous, sulphate of baryta is inert.
- *Mixture.*—Dilution may retard or accelerate the action of a poison.[1]

3. Point of application—Skin, lungs, mucous and serous membranes.

4. Condition of the body.
- *Habit*—generally lessens the action of poisons, e.g. *arsenic eater*.
- *Idiosyncrasy*—increases or may lessen the action of poisons.
- *Disease*—generally lessens, but in some cases increases the action of poisons.

GENERAL EVIDENCE OF POISONING.

It will now be necessary to consider briefly the general evidences of poisoning, in order to determine whether a death alleged to be due to poison is not really the result of disease. For convenience of description, this subject will be divided into five sections:—

1. Evidence from the Symptoms.
2. Evidence from the *Post-mortem* Appearances.
3. Evidence from Chemical Analysis.
4. Evidence from Experiments on Animals.
5. Moral Evidence.

1. Evidence from the Symptoms.—As a general rule, except in cases of slow poisoning, when the poison may be so administered as to simulate disease, the symptoms come on suddenly, while the person is in apparent health. In cases of suspected homicide, this suddenness in the accession of the symptoms is particularly to be noticed, and we may have to decide as to the probabilities of accident, suicide, or homicide. Here collateral evidence must be our guide. The slowness, obscurity, and irregularity of the symptoms are more in favour

[1] Dilution lessens the activity of some poisons, by prolonging the time necessary for their absorption; but in the case of powerful irritants, which act through the blood, moderate dilution increases their activity, by enabling them to enter the vessels more easily. Oxalic acid is an example of the effect of dilution as a modifying agent in its action. A small concentrated dose acts as an irritant; diluted, it is soon absorbed, and quickly causes death.

of homicide than either accident or suicide. But it must also be borne in mind that the invasion of many diseases is sudden, as is the case with cholera, gastritis, and some others.

Certain conditions of the system more or less modify the effects of some poisons. Thus, sleep delays the action of arsenic; and this may also be the case with other poisons. Intoxication has also been said to exert a retarding power over the action of certain poisons. This is probably more apparent than real, the fact being that the symptoms in the cases observed are masked.

Much more important, however, is the influence of disease. Large doses of opium are well borne in mania, delirum tremens, dysentery, and tetanus; whereas it is well known that even small doses of mercury in cases of Bright's disease of the kidney, or in children recovering from any of the eruptive fevers, have produced dangerous salivation.

The symptoms of poisoning go on from bad to worse in a steady course; but there may be remissions, followed, under treatment, by their entire disappearance, no ill effect remaining. Remissions are most likely to occur in slow poisoning with the metallic irritants from fear of detection or cunning on the part of the poisoner to imitate the progress of disease. In nervous affections, all the symptoms must be taken into consideration, and these will be found to differ from those of any known poison. The history of the case should also have due attention paid to it.

In poisoning, the symptoms appear soon after food or drink has been taken. This is open to the objection that apoplexy has occurred immediately after a meal. The probative value of the above statement is, however, increased if several persons have been similarly affected after partaking of the same dish, especially if the symptoms followed within a short time—under four hours—of the meal. But it must also be remembered that all persons are not affected alike by the same poison. Again, the diagnostic value is weakened if it can be proved that the person or persons affected have taken nothing in the way of food for two or three hours previously.

The flesh of animals poisoned by accident, or intentionally, may seriously affect those who eat it.—As a case in point may be mentioned the injurious effects produced in some persons who had partaken of the Canadian partridges imported to this

country some years ago, and which had probably eaten of some poisonous berries during the severe winter of that year.

Poisons may be introduced into the system otherwise than by the mouth ; that is, they may be placed in the vagina or rectum, or inhaled when volatile poisons are used. Sometimes a poison has been introduced into the medicine, or a poisonous draught substituted for the one prescribed. In any case, where suspicious symptoms suddenly occur, the poison has most probably been taken in from half-an-hour to an hour previously, and it is of special importance to note the period of time that may have elapsed between the accession of the symptoms and the last meal, or administration of medicine.

When called in to a case of suspected poisoning, and in many cases where no suspicion at the time arises, the medical attendant should pay attention to the following points :—

1. The time of the occurrence of the symptoms, and their character.
2. The time that has elapsed between their commencement and the last meal, dose of medicine, etc.
3. Have the symptoms continued without intermission or remission, and in an aggravated form, till death ?
4. The order of their occurrence.
5. The previous health or illness of the patient.
6. Have the symptoms any relation to a particular meal or article of food, etc. ?
7. If patient has vomited, have the vomited matters, especially the first, been carefully preserved ?
8. Preserve all vomited matters, food, medicines, etc.
9. How many were at the meal ? and what was taken common to all or only by a few ?

2. Evidence from *Post-mortem* Appearances.—The morbid appearances found in cases of poisoning will be treated more in detail when each poison, or group of poisons, comes to be separately considered. A caution may be given here against allowing the *post-mortem* signs of disease or external injury to exclude the idea of poisoning ; for death may to all appearance be the result of disease or injury, and yet be caused by poison. An attention to the *post-mortem* appearances is important in all cases ; for in many instances, where the symptoms were unknown to the experts at the time the inspection was made, they were subsequently found to correspond with the morbid changes which the autopsy revealed. The normal appearance of the stomach is white or nearly so, except during

digestion, when it is reddened; yet we may sometimes come across cases in which the mucous membrane of this organ may be found so reddened as to lead to a suspicion of poisoning. The knowledge of this fact, and the absence of symptoms will prevent an error in diagnosis. Ulceration from disease and from irritant poisoning must be distinguished. In that due to disease, the ulcers formed are, as a rule, small and circumscribed; in those from poison, there is diffused inflammatory redness over other parts of the stomach, and even in the intestines; and the poison, as in the case of arsenic, may be found adhering to the sides of the ulcer. Ulceration is more frequently the result of disease than of the action of poisons. Perforation of the stomach or intestines may be due to ulceration or to corrosion. The condition of the mouth and gullet will help the diagnosis. The appearance of the ulcer and the parts around it, together with the hints just given, must guide the diagnosis. Of *post-mortem* softening little need be said, beyond stating that it very rarely occurs, and is of course not preceded by symptoms. (For the diagnosis between inflammatory redness of the intestines and *post-mortem* staining, see page 46.)

3. Evidence from Chemical Analysis.—The objects of a chemical analysis are to determine:—(1) The presence and nature of the poison. (2) The proportion or quantity of the poison taken. (3) The solution of certain questions connected with the administrations of the poison.

The detection of poison in the body is of course the most important proof of poisoning; but it may be suggested that the poison was introduced after death, which, to say the least, is a most ingenious line of defence, but which, at the same time, must be held to be highly improbable, and impossible if found deposited in one or more of the solid organs. Again, granting that poison has been taken, is it the cause of death? This question may arise when injuries are found on the body, and it then becomes a matter of importance to know something of the symptoms which preceded death, and the morbid appearances found after death. The case of the girl who took arsenic to escape a beating by her father, is a case in point. The father was tried for causing the death of the girl by undue severity, but it was subsequently shown that arsenic self-administered was the true cause of death. The poison may

disappear from the body. This disappearance may be effected by vomiting, purging, or by the urine, or the poison may become absorbed and decomposed. The person poisoned may live sufficiently long to allow of the entire elimination of the poison, and yet die of the induced exhaustion. (See case of Dr. Alexander, *ante.*)

Some poisons, especially those which are sparingly soluble, are with difficulty removed from the stomach, even by the most incessant and violent vomiting. This is notably the case with arsenic, which adheres to the mucous coat of the stomach with considerable tenacity. But even after all traces of the poison have left the stomach, it may be detected in the solid viscera.

Temporary deposit of poison in the organs of tissues (TAYLOR): –(1) The Liver. (2) The Kidneys. (3) The Spleen. (4) The Heart. (5) The Lungs. (6) The Muscles. (7) The Brain. (8) The Fat. (9) The Bones.

With regard to arsenic, the following Table, taken from Taylor, is of importance, as showing the amount of the poison which may be found in the liver at certain intervals:—

After taking the Poison.	Total weight of Arsenic.
In $5\frac{1}{2}$ to 7 hours	0·8 grains.
$8\frac{3}{4}$ hours	1·2
15 hours	2·0
17 to 20 hours	1·3
$10\frac{1}{2}$ days	1·5
14 days	0·17
17 days	*nil*

Is it necessary that the poison should be found in the body or in the evacuations, to lead to a conviction for poisoning? On this point, Christison was of opinion that if the symptoms, *post-mortem* appearances, and moral evidence are very strong, it is not necessary that the poison be found in order to establish a charge of poisoning. This opinion was also supported by the late Dr. Geoghehan, Professor of Medical Jurisprudence in the Royal College of Surgeons, Ireland, and was also virtually acted upon in the case of Palmer, where the non-detection of strychnia was strongly dwelt upon by the counsel for the defence, but without success. Many of the vegetable poisons almost defy detection, except by the symptoms, *post-mortem* appearances, and some experiments on animals of doubtful

value. The detection of poison in the food taken, or in the vomited matters, is of great importance; but it is of still greater importance if it can be found in the urine, drawn from the bladder, this being a proof that it has passed through the system. Here again a caution is necessary—for it must be remembered that poisoning may be *feigned* or *imputed*—the poison being mixed with the food and evacuations, and an innocent person accused.

The following suggestions should be carefully considered by every analyst when substances are sent to him for examination:—

He should carefully note when and from whom the substances were received; in what state they were received—secured, or exposed; the number of articles, and whether properly labelled. He must make the analysis himself, and state where it was made. The character and nature of the substances examined should be noted, and he must be prepared to give an outline of the methods or processes used for their determination. He must also be able to guarantee the purity of his reagents, and be prepared to answer the following questions:—

1. Is the poison free or combined?
2. What is the strength and quantity found?
3. Could the poisonous substance exist naturally?
4. How much of the poison found is a fatal dose?
5. If no poison is found, is there anything noxious or injurious to health?

The analyst may have the following submitted to him for examination:—(1) Substances found on the accused, or in the room, or on the person of the deceased. (2) Articles of food. (3) Vomited matters, urine, etc. (4) Contents of the stomach. (5) Solid organs of the body.

He may also have his results called in question for the following reasons:—(1) Purity of his reagents. (2) Faulty processes. (3) Hasty conclusions. (4) Experiments on animals.

Death may undoubtedly be due to the action of a poison, and yet its presence may fail to be detected, due to—(1) The nature of the poison—strychnia, hydrocyanic acid, etc. (2) Vomiting and purging. (3) Absorption and elimination. (4)

Decomposition—phosphorus, chloral hydrate, chloroform. (5) Smallness of the dose.

(For directions for conducting a *post-mortem* examination in cases of poisoning, see page 65.)

4. Evidence from Experiments on Animals.—The evidence derived from experiments on animals with the contents of the stomach and vomited matters must not be too implicitly trusted, as these may give rise to vomiting and other symptoms when no poison is present. All animals are not alike affected with man by the same poisons; and it appears that the dog and the cat are the only animals that at all approach man with regard to the effects produced. Experiments on the lower animals are useless to decide—(1) The fatal dose of any poison. (2) The rate of absorption, deposition, or elimination of poisons. (3) The rapidity of the action of certain poisons.

In the case, however, of some vegetable poisons, the effects produced on animals by a portion of the substance taken by the person suspected of having been poisoned, may afford corroborative evidence of poisoning. In the case of Lamson, executed for poisoning his brother-in-law with aconite, experiments on animals formed the chief evidence against the accused.

5. Moral Evidence.—The moral evidence of poisoning is generally furnished by the common witnesses of the Crown; but the value of this kind of evidence, in many cases, can only be fully appreciated by a medical witness. To render this part of the subject as complete as possible, a few remarks may not be out of place. The suspicious conduct of the prisoner before and after the event, the recent purchase of poison, the mode of administration, the object of the prisoner in getting rid of his supposed victim, and the fact of several persons being alike affected, should be carefully noted down. The anxiety evinced during the illness of the deceased, and the hurry in the funeral arrangements, as showing an over-anxiety to remove all traces of his guilt, are suspicious. The probability of suicide is weakened by the state of the mind and the nature of the dying declarations of the deceased. In the case of a person indicted for poisoning, evidence to show motive in another case is admissible. (R. *v.* Geering, 18 L.J. [M.C.] 215; R. *v.* Heeson or Johnson; R. *v.* Garner, 3 F. & F. 681.)

Lastly, it remains to be considered—

What is the duty of a Medical Man who suspects the Action of Poison in a Patient on whom he is in attendance?

In the case of R. *v.* Wooler, Baron Martin, who tried the case, in his charge to the jury, stated that, in his opinion, the medical men in attendance ought, "when the idea of poisoning struck them, to have communicated their suspicion to the husband, if they did not suspect him; and if they did suspect him, they ought to have gone before a magistrate." Suppose they had acted as the learned Judge suggested, and spoken to the husband, who, had he been guilty, would in all probability have desisted from his terrible design for a time, then a great criminal would have been let loose on society, and without punishment. Then, again, had they applied to the magistrates, the delay caused by the indecision of the magistrates how to act in so delicate a case would have allowed the criminal to remove all traces of his design, and the means of testing their suspicions would have been lost; and, along with this, would have been lost the professional character and fortunes of the authors of the investigation. "There is a third course," said the late Sir R. Christison, "and in my opinion it is the fittest of all:—When the medical attendant is satisfied of the fact of poisoning, he should communicate his conviction to the patient himself. His predicament, in every other way, is so embarrassing, that he ought not to be deterred by the chance of injury to his patient from making so dreadful a disclosure." (See an account of the same course being adopted in the case of Mr. Blandy by his physician, Dr. Addington, reported in Howell's *State Trials*, vol. xviii.)

[TABLE

Summary of the General Evidence of Poisoning, in a Tabular Form

Poison.	Natural Causes.
1. The symptoms come on suddenly, and rapidly progress.	1. Many diseases come on suddenly—cholera, gastritis, etc.—and run a rapid course to a fatal termination.
2. The symptoms begin while the person is in sound health.	2. Some acute diseases begin under like circumstances.
3. The symptoms of poisoning go on from bad to worse in a steady increase.	3. This is also the case with many common diseases.
4. Uniformity in the nature of the symptoms.	4. The uniformity of the symptoms is common to many diseases; but in some cases the absence of uniformity may be a proof of disease.
5. The symptoms come on immediately after a meal.	5. Apoplexy, colic, cholera, and some other diseases, may follow a meal. But the fact that some hours have elapsed since the last meal is against the probability of poisoning.
6. Several persons are attacked, after partaking of the same meal, with the same symptoms.	6. As a general principle it may be stated that there is no disease likely to attack several persons at once, but there are cases on record of this having occurred.
7. Poison found in the food, vomited matters, urine, etc.	7. Poison may be mixed with the food, etc., in cases of imputed poisoning.

Table giving the names of Diseases the Symptoms of which resemble those the result of Irritant Poisons, together with such points of difference as may assist in distinguishing the one from the other :—

Irritant Poison.—Symptoms of violent irritation in one or more portions of the alimentary canal. Pricking and burning of the tongue and mouth, and intense thirst, frequently accompanied with great constriction in the throat. Great abdominal pain and tenderness. Vomiting and purging are also usually present. The skin is hot and cold at intervals; the pulse small, frequent, and irregular. In the last stage the skin may become icy-cold. *An acrid, metallic, or burning taste in the mouth precedes the vomiting.* The vomit and alvine discharges are

generally mixed with *blood*. Death occurs in from six hours to two days and a half.

Cholera.—Extreme and sudden prostration. The breath is cold to the hand in the last stages. The body is cold, shrivelled, and livid, or of a leaden hue. Vomiting and purging are present; the former is never bloody, the latter resembling rice-water. The thirst is intense, and in this particular alone resembles the effects of irritant poison. Death in from one to two days, or even less.

English Cholera.—In this disease all the symptoms of irritant poisoning are present. Pain in the belly, and vomiting. But in this disease the vomit and alvine discharges are *never* bloody, most frequently bilious. *An acrid taste in the mouth and throat succeeds the vomiting.* This is due to the acrid nature of the vomited matters. The stools contain bile in English cholera; in irritant poisoning, sometimes blood. Death is rare within three days.

Gastritis.—Acute idiopathic gastritis is so rare in this country as scarcely to need description. Most of the cases recorded of acute gastritis have been found to be due to irritants. We must, therefore, consider the period and order of the occurrence of the symptoms in relation to the last meal. Costiveness of the bowels would point to the presence of gastritis or enteritis, violent purging and vomiting to irritant poisoning.

Enteritis.—Though more common than gastritis, enteritis is a rare disease. The bowels are generally *confined*. Tubercular and aphthous inflammation of the intestines may simulate irritant poisoning, especially chronic poisoning by arsenic. The *post-mortem* and a chemical analysis will reveal the true cause of death.

Peritonitis.—In the early stages of the disease vomiting is rare, and constipation is the rule, with marked tenderness over the whole abdomen. The morbid appearances in the peritoneum are seldom caused by irritants.

Perforation of the Stomach.—The symptoms supervene immediately after a meal; the pain, which is very acute, gradually extending over the abdomen. In most cases the patient has suffered for some time previously from dyspepsia.

Hernia.—Examine the seat of pain, the cause will be soon detected. But an omental hernia may be present, giving rise to twisting pain at umbilicus. The *post-mortem* will decide.

Intussusception of the Bowels.—Pain, sudden and confined to one spot below the stomach. Vomiting is present *without* purging, thus differing from diarrhœa and cholera. After a time the vomit becomes fæcal.

Colic.—May be confounded with poisoning by the salts of lead. If lead be taken in large doses, it produces the symptoms common to irritant poisons added to those of colic. In chronic lead poisoning, the blue line round the gums, the aspect of the patient, and history of the case, will point to the true cause of the symptoms. Lead colic is also generally accompanied with extreme depression of spirits.

Internal Rupture of Organs.—Rupture of the stomach, duodenum, gall bladder, and impregnated uterus, is of rare occurrence. The autopsy will show the true cause of death.

TABLE giving the names of Diseases the Symptoms of which resemble those the result of Narcotic Poisoning, together with such points of difference as may assist in distinguishing the one from the other:—

NARCOTIC POISONING.—Giddiness, headache, drowsiness, and considerable difficulty in keeping awake. Paralysis of the muscles, convulsions, ending in profound coma and death. The symptoms of narcotic poisoning begin not later than an hour, or at most two hours, after the poison is taken, except in the case of poisonous fungi and spurred rye, when a day or two may elapse. The symptoms of narcotic poisoning advance gradually. The person may, in *most* cases, be roused from the deepest lethargy. The pupil in opium-poisoning is, as a rule, *contracted.* Recovery seldom occurs after twelve hours; in most cases, death takes place in six or eight hours—the shortest time being three hours.

APOPLEXY.—In some cases apoplexy is preceded by warning symptoms—headache and giddiness. As a rule, apoplexy is a disease of old age, and of stout, plethoric people. If the symptoms do not come on for some hours after food or drink has been taken, this disease is to be suspected; but it may occur *at* or *immediately* after a meal, too soon to be the result of the action of narcotics—ten to thirty minutes always elapsing before these poisons act. Apoplexy generally comes on suddenly, coma at once present. It is seldom possible to rouse the person when the sopor of apoplexy is fully developed. The pupils in apoplexy are *usually dilated;* but should the effusion of blood take place into the pons Varolii, the pupils may be contracted, hence closely simulating opium poisoning. Apoplexy may last for days, or death may occur in an hour.

EPILEPSY.—Loss of consciousness and presence of convulsions mark this disease; and in these it resembles poisoning by prussic acid. Epilepsy is in most cases a chronic disease. Warnings—*aura epileptica*—are often present. The fit begins violently and abruptly. The paroxysm generally lasts for some time, and death rarely occurs during the first attack.

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Table showing Points of Difference in the Action of Corrosive and Irritant Poisons.

Corrosives.	Irritants.
1. Destruction of the parts to which they are applied. No remote action on the system.	1. Irritation of the parts to which they are applied producing inflammation. Remote action present in most of the irritants.
2. Symptoms supervene immediately they are swallowed, and consist of a burning, scalding pain felt in the mouth, gullet, and stomach.	2. Symptoms may rapidly supervene after they are taken, or some delay may occur, due to the state of concentration or dilution of the poison. Pain in the stomach and bowels, more or less severe, is always present with the other signs of irritation.
3. Death may result from— (1) Shock. (2) Extensive destruction of the parts touched. (3) Starvation. (4) Suffocation, the result of œdema, or spasm due to acid in larynx.	3. Death may result from— (1) Shock. (2) Irritation, causing convulsions. (3) Protracted suffering. (4) Starvation.
4. *Post-mortem* appearances: corrosion and extensive destruction of tissue.	4. *Post-mortem* appearances: irritation, and signs of inflammation, ulceration, etc.

GENERAL TREATMENT OF CASES OF POISONING.

The principal modes of procedure are as follows:—

1. To remove the poison from the digestive tract, or neutralise it or render it insoluble by the administration of suitable antidotes.

2. To overcome the effects of that which has been absorbed.

3. To promote its elimination.

4. To alleviate dangerous symptoms, and endeavour to keep the patient alive until the effects of the poison have passed off.

To forcibly empty the stomach, emetics may be administered or other means used to induce vomiting, or the stomach pump or tube may be employed.

Suitable emetics are sulphate of zinc in thirty-grain doses

dissolved in warm water, a dessert-spoonful of mustard in half a pint of warm water, ipecacuanha wine in tablespoonful doses, copious draughts of hot water. Tartar emetic and sulphate of copper should be avoided, except in cases of phosphorus poisoning, when the latter may be used. The hypodermic injection of $\frac{1}{10}$ grain of apomorphine is a very useful emetic, especially in cases of narcotic poisoning. Irritation of the fauces with the finger promotes vomiting, and may be useful in the absence of an emetic.

The stomach tube or pump is most useful in that it is under the control of the operator and enables him to thoroughly wash out the stomach. After passing the tube, previously lubricated with vaseline or glycerine, through the œsophagus down to the stomach, a pint of warm water should be first injected before withdrawing any of the contents. By alternate injection of water and its withdrawal, the stomach may be efficiently cleansed, and at the same time solutions of suitable antidotes may be passed into it. It must be remembered that neither the stomach pump or syphon tube, nor emetics, are to be used in cases of poisoning with corrosives, with the exception of carbolic acid. The tube should be used with great caution in cases of irritant poisoning.

Antidotes are remedies which counteract the effects of poisons. They act mechanically, *e.g.* flour and water, chalk mixture; chemically, as magnesia and chalk in mineral acid poisoning, alkaline sulphates in lead and barium poisoning; and physiologically, as antagonists, such as morphine and atropine, atropine and physostigmine, strychnine and chloral hydrate.

To counteract the effects of the portion of the poison absorbed, special treatment is necessary: purges and diuretics may be called for; artificial respiration may be necessary; cardiac depressants require cardiac stimulants; the cold douche as a restorative and external warmth are desirable in certain cases. Sedatives may be administered to alleviate convulsive seizures. Tracheotomy may be required in cases with laryngeal complications; and pain, exhaustion, excessive vomiting or purging are to be treated by appropriate remedies.

EXAMINATION OF THE CONTENTS OF THE STOMACH, VISCERA, ETC., FOR POISON.

The number and condition of the vessels received should be noted and copies made of any affixed labels.

The appearance, smell, colour, and reaction to test paper of the contents should be noted, and their weights and volumes determined. All jars, wrappers, labels and seals should be preserved for future reference.

The stomach contents should be carefully examined in reference to their nature, colour, and smell, and the presence or absence of any abnormal constituents. The mucous membrane of the stomach should be examined with the naked eye and by the aid of a lens, the surface washed with distilled water, and the washings added to the contents.

There is often some clue as to the nature of the poison afforded, and the investigation should be made for it first; the presence or absence of other poisons, however, must be determined. If there be no clue, then a systematic examination must be carried out. The poison must be looked for not only in the contents of the stomach, but in the viscera as well; it must be remembered that poison may be introduced into the stomach after death.

Volatile poisons, such as alcohol, chloroform, prussic acid, may be separated by distillation after acidulation with tartaric acid. Arsenic is best separated by drying the organic material, and distilling after adding strong hydrochloric acid.

Other metallic poisons may be tested for, with or without destruction of organic matter. To destroy the organic matter, the *moist method* is the one in general use: After reducing the contents of the stomach or the viscus to a pulp, they are mixed with distilled water to the consistency of thin gruel, and placed in a flask with some crystals of potassium chlorate—half an ounce to each pound of the liquid. Pure hydrochloric acid is added, and the flask gently heated on a water-bath, a mixture of chlorine and oxides of chlorine are given off and gradually break up the organic matter, converting at the same time any mineral poison present into the chloride. This procedure is followed until the material becomes quite limpid, more chlorate or hydrochloric acid may be added if necessary. It is then transferred to an evaporating dish and heated on the water-

bath until the smell of chlorine disappears. It is then filtered while hot, to allow chloride if present to pass through ; a stream of sulphur dioxide is passed through the filtrate when cold, to reduce any metals present to a lower state of oxidation. Silver chloride will not pass through the filter in this process, so it has to be dealt with in a special manner.

In making a systematic analysis, volatile poisons must be tested for first, then ascertain the presence or absence of alkaloids, after which the inorganic poisons must be dealt with.

CHAPTER II.

DIVISION I.—CHEMICAL.

CORROSIVE POISONS.

THE MINERAL ACIDS

General Characters.—The mineral acids have no remote effects on the system; their action is purely local. They are seldom used for the purpose of homicide, except in the case of young children. By suicides they are more frequently employed.

The *Symptoms* common to the action of these acids supervene *immediately* the acid is swallowed, and consist in a sensation of burning in the mouth and gullet. Dreadful pain is felt in the stomach, attended with constant eructations, and vomiting of a brownish or blackish matter, mixed with blood. Mucus, together with, in severe cases, portions of the mucous membrane of the stomach, may be detected in the vomited matters, which have an intensely acid reaction, changing the colour and destroying the texture of cloth or other material on which they may fall. The act of swallowing is attended with intense pain, and not infrequently is rendered quite impossible. The thirst is intense, the bowels are confined, and the urine is diminished in quantity. The pulse is small and weak, and the skin clammy and cold. Respiration is performed with difficulty, and the countenance expresses the most intense anxiety. Sometimes, when the upper part of the windpipe is implicated, there is more or less cough and difficulty of speech. Death may even result from suffocation—the skin, in this case, presenting a cyanosed appearance. The mouth is excoriated, the lips shrivelled and blistered. In children, when the acid has been poured far back into the mouth, by forcing the bottle

backwards before emptying it of its contents, the mouth may more or less escape injury, and the signs in it of corrosive poisoning be absent. The teeth may become loose, and fall out of the mouth. The mental faculties remain clear, death generally coming on suddenly, the patient dying convulsed or suffocated. The period at which death ensues is very variable, and considerable power for locomotion may be retained by the sufferer, though, as a rule, he is found writhing in exquisite agony on the floor or elsewhere. Some cases recover, leaving the coats of the stomach more or less injured, and the general health greatly impaired.

Post-mortem Appearances.—The body externally is healthy. The lips and external parts of the body, which have come in contact with the acid, are charred. The mucous membrane of the mouth, shrivelled and eroded, is whitish, yellowish, or brownish, sometimes appearing "as if it had been smeared with white paint" or thin arrowroot. Many of the appearances above described will depend upon the rapidity with which death has followed the swallowing of the poison. The mouth, gullet, and trachea may alone show any signs of the corrosive action of the poison, and it is important to remember that death may be due to sulphuric acid, and yet the acid may never have reached the stomach. In one or two cases where the poison was poured into the mouth during sleep, and in the case of children in whom the mouth was held open, there were no signs of the poison on the lips, and the mouth even escaped in one or two cases. The stomach, in some cases more or less contracted and perforated by the corroding action of the acid, may contain a dark grumous liquid, the acidity of which will depend upon the treatment adopted, or the length of time that may have elapsed from the swallowing of the acid to the fatal termination. The stomach also appears as if carbonised, this being due to the action of the acid on the effused blood; no such appearance being produced when sulphuric acid is poured into the dead stomach. Corrosive action may be found in the duodenum. In cases where the patient has survived from sixteen to twenty hours, the small intestines have been found inflamed. The blood, Casper states, is never fluid in acute poisoning by sulphuric acid, but always "syrupy at least, and sometimes ropy; it has a cherry-red colour, and acid reaction." Sulphuric acid is also said to possess powerful antiseptic

properties, and that bodies of those who have died from its effects remain long fresh.

There are two things which may render the diagnosis difficult—(1) Gastric ulcer. (2) *Post-mortem* digestion of the stomach.

Gastric ulcers vary in size from that of a fourpenny-piece to that of a florin, or larger. In shape, they are round or oval, and present the appearance of shallow but level pits, with sharp, smooth, vertical edges—appearing as if they had been punched out. The peritoneal opening is smaller than that on the internal surface of the stomach. The absence of injury to the mouth and gullet will distinguish gastric ulcer and *post-mortem* softening from the action of corrosive poisons.

General Treatment.—Chalk, carbonate of magnesia, the plaster from the walls or ceiling of the apartment stirred in water, and followed by diluent drinks—barley water, linseed tea, etc. The use of the stomach pump is contra-indicated.

SULPHURIC ACID.

Forms.—Sulphuric acid occurs in two forms—*concentrated* and *diluted.*

Characters.—Concentrated sulphuric acid or oil of vitriol (specific gravity, 1·800 to 1·845), as it is found in commerce, is a heavy, oily, colourless, or slightly brownish-coloured liquid, not fuming when exposed to the atmosphere; but, when added to water, causing a rapid increase of temperature, which may crack the glass vessel in which the mixture is made. Sulphuric acid chars and destroys the texture of organic bodies placed in it. *Dilute sulphuric acid* is a colourless, strongly acid liquid, reddening litmus, and charring paper dipped into it when subsequently dried, care being taken not to scorch the paper.

Symptoms, etc.—The symptoms and *post-mortem* signs have been already described, pp. 262 *et seq.*

Chemical Analysis and Tests.—The acid will have to be examined under the following heads:—(1) Simple, concentrated acid. (2) Dilute acid. (3) Mixed with organic liquids, food, vomit, etc. (4) On the clothes of the person injured.

I. Concentrated Acid.

1. *Chars Organic Matter.*—A piece of wood or paper placed in the strong acid rapidly becomes blackened.

2. *Heat when added to Water.*—Equal quantities of acid and water added together produce intense heat.

3. *Evolution of Sulphurous Acid.*—When boiled with chips of wood, copper cuttings, or mercury, fumes of sulphurous acid are evolved, detected by their sulphur-like odour, and by their power of first bluing and then bleaching starched paper dipped in iodic acid.

II. Dilute Acid.

1. *Chars Paper.*—This only occurs when the paper is dried by the aid of heat, subsequently to moistening it in the dilute acid.

2. *Precipitation of Sulphate of Barium.*—A solution of the nitrate or of the chloride of barium is precipitated by sulphuric acid in the form of a white insoluble powder, unaffected by nitric or hydrochloric acid, even when heat is applied. This test is so delicate, that a liquid containing $\frac{1}{25000}$th part by weight of the acid is precipitated by either of the test solutions.

3. *Action of Heat.*—The dilute acid is entirely volatilised by heat.

III. Mixed with Organic Liquids, etc.

In tea, coffee, or beer, the mode of applying the tests are the same, the mixture being previously filtered, or the acid separated from the organic mixture by dialysis, or the following cautions are necessary :—

Objection A.—Alum, or any acid sulphate, would give all the reactions with the nitrate and chloride of barium.

Answer A.—Evaporate a portion of the doubtful liquid ; if pure acid, there will be no residue, sometimes only the *slightest trace* of sulphate of lead.

Objection B.—Erroneous estimation of free sulphuric acid, in consequence of the presence of some saline or neutral sulphates.

Answer B.—Evaporate as before. The free sulphuric acid separated by warming, the liquid is then added to a known weight of powdered carbonate of baryta until effervescence ceases. The resulting precipitate, when weighed, represents the free sulphuric acid present.

Calculate in the following manner—

$$Ba,CO_3 + H_2SO_4 = Ba,SO_4 + H_2O + CO_2.$$
$$Ba,CO_3 = 197.$$
$$H_2SO_4 = \ 98.$$
$$CO_2 = \ 44.$$

In the above equation, 98 parts of H_2SO_4 take the place of 44 parts of CO_2. If, therefore, 100 grains of Ba,CO_3 renders the liquid neutral, the amount of free SO_4 present will be represented by the increased weight of the precipitate in the proportion of 54 to 98, the difference between 44 and 98 the equivalent of $CO_2 + SO_4$.

To extract the acid from organic mixtures, digestion with alcohol is required: filter and neutralise the filtrate with caustic potash, evaporate to dryness, and dissolve the residue in distilled water acidulated with hydrochloric acid; the previous tests may then be applied. Extraction with alcohol leaves behind combined acid in the form of sulphates. The presence of free acid in the filtrate or original mixture may be detected by the change of tropaeolin solution from yellow to crimson or ruby colour when added to it; or on adding a few drops of the mixture or filtrate to a solution of potassio-tartrate of iron B.P. in water, of a yellow tinge and to which potassium sulpho-cyanide has been added, the liquid changes from a yellow to port-wine colour.

IV. Stains on the Clothes, etc.

1. The strong acid changes the colour of black woollen cloth to a dirty brown, the edges of the spots assuming a reddish tint after a few days. The dilute acid on the same cloth produces a red stain, which in time becomes brown.

2. The spots made by the strong acid remain damp for some time—strong sulphuric acid, having a great affinity for water, continually absorbs moisture from the atmosphere.

3. The spot should be cut out, boiled in distilled water, or digested with alcohol, filtered and tested for free sulphuric acid.

4. A portion of the cloth not touched by the acid should be tested, in order to show that the sulphuric acid found is not due to sulphates present in the cloth.

5. An acid sulphate—bisulphate of potash—gives a reddish

stain to black cloth like that produced by the dilute acid. Test for this salt by incineration.

Fatal Period.—Average time before death ensues is from two to twenty-four hours. The shortest time was one hour, but in children death may be instantaneous. Life, however, may be prolonged for some weeks, or even months.

Fatal Dose.—One drachm in a healthy adult has proved fatal; on the other hand, however, four ounces have been swallowed without being fatal.

Treatment.—As before mentioned.

N.B.—This acid of late years has given rise to several actions, it having been employed to disfigure the person by throwing it in the face.

NITRIC ACID.

Forms.—Strong nitric acid, and dilute nitric acid.

Characters.—This acid is commonly known as *aqua fortis*, or red spirit of nitre. It is seldom used as a poison.

The *strong acid* varies in colour from a pale yellow to a deep orange. The colour is due to admixture with peroxide of nitrogen. On *cloth* and *articles of dress* it produces *yellow stains*, which are darkened by the application of an alkali. If poured on copper cuttings, reddish fumes of nitrous acid are given off. *Dilute nitric acid* is a colourless acid liquid, not precipitated by nitrate of barium or nitrate of silver, showing absence of sulphuric and hydrochloric acids. All its alkaline salts are soluble in water.

Symptoms.—The symptoms have been before described, and are similar to those produced by sulphuric acid, though not quite so severe. The *vapour* of this acid has caused death in eleven hours by congestion of the bronchial tubes and lungs; care should, therefore, always be taken not to inhale the fumes given off by the acid in the manufacture of gun cotton, etc.

Post-mortem Appearances.—Same as the mineral acids generally, but the tissues touched are turned yellow, and if bile be in the stomach it is turned green. The stomach is rarely perforated.

Chemical Analysis.—Nitric, like sulphuric, acid will be examined under four heads; but being a volatile acid, easily decomposed, and also having its nature changed by contact

with organic substances, its presence on clothes may fail to be detected after a few weeks. The colour of the stain on cloth may also remain, although the acid has been entirely removed by washing. 1. Strong, concentrated acid. 2. Dilute acid. 3. Mixed with organic liquids, etc. 4. On the clothes of the person injured.

I. Concentrated Acid.

1. *Volatility.*—When exposed to the atmosphere, strong nitric acid gives off colourless or orange-coloured acid fumes. Heated in a watch-glass, it is evaporated without residue.

2. *Action on Organic Matter.*—The acid leaves on woollen clothes a *yellow-coloured stain*, which is darkened by the addition of an alkali. The colour of the stain is due to the formation of picric acid.

3. *Action on Metals.*—Gently heated in a test-tube with copper filings, orange-coloured fumes are given off, which redden but do not bleach litmus paper. Starch paper treated with iodide of potassium becomes purple.

4. *Solution of Gold.*—If a small portion of gold leaf be put into the acid, no effect is produced; but on the addition of concentrated hydrochloric acid, the metal is rapidly dissolved.

II. Dilute Acid.

1. Absence of sulphuric and hydrochloric acids, proved by no precipitate being formed with nitrate of barium and nitrate of silver.

2. It does not char paper when the paper is heated, as is the case with sulphuric and hydrochloric acids.

3. If a piece of filtering paper be dipped into a solution of the acid saturated with carbonate of potash, dried and ignited, it will burn like touch-paper.

4. The acid liquid, saturated with carbonate of potash and evaporated, deposits *fluted* prisms which do not effloresce or deliquesce on exposure. Neutralised with soda, the crystals are of a *rhombic* form.

5. A crystal, so formed, moistened with distilled water on a plate, and then heated with strong sulphuric acid and allowed to cool, gives with—

(1) A piece of *green sulphate of iron*—a dark green ring round the crystal.
(2) A small portion of *morphia*—a rich orange colour, a yellow liquid being formed.
(3) A small portion of *brucia*—a blood-red colour.

6. If an aqueous solution of diphenylamine be added to a solution containing nitric acid, in a test-tube, and pure sulphuric acid be poured down the side of the tube to form a layer at the bottom, a blue colour forms at the junction of the two liquids.

III. Mixed with Organic Liquids, etc.

Due to the measures employed by way of treatment the vomited matters may be neutral and yet nitric acid be present. The method adopted with viscid and turbid organic mixtures is to dilute them with pure water, and then filter. If the filtrate be acid, it is neutralised with carbonate of potash, evaporated, and then set aside to crystallise, and the crystals purified by digesting them in ether or alcohol. The crystals are again dissolved and re-crystallised. The tests just mentioned should then be employed. It should be remembered that nitric acid has a strong tendency to combine with solid organic structures, and to become decomposed. The parts of the body stained by the acid should, therefore, be digested in water at a gentle heat, the liquid cooled, filtered, and neutralised with carbonate of potash, and then examined for nitre.

IV. Stains on the Clothes, etc.

Macerate the piece of cloth in distilled water by the aid of heat. If the solution be acid, neutralise with carbonate of potash, and filter. Test the solution as before mentioned.

The action of the dilute solution of caustic potash on the following stains on cloth is characteristic :—Nitric acid stain becomes of a clear orange tint. Iodine stain disappears. Bile stain remains unchanged.

Fatal Period.—Death may take place in an hour and a half, or life may be prolonged for some months.

Fatal Dose.—Two drachms ; recovery has taken place after half a fluid ounce of the strong acid has been taken.

Treatment.—As before mentioned when speaking of the acids generally.

HYDROCHLORIC ACID.

Forms.—Strong and the dilute acid. It is known as muriatic acid, or spirits of salts.

Characters.—*Strong hydrochloric acid* is either colourless or has a bright yellow tint, due to the presence of the perchloride of iron. It fumes in the air, and gives rise to dense white fumes when a glass rod moistened with ammonia is held over the surface of the acid. The *dilute acid* is colourless.

Symptoms.—Poisoning with muriatic acid is so rare that the symptoms have not been well studied, but they do not appear to differ much from those produced by the action of the other acids. It does not stain the skin, but may darken the mucous membranes. The fumes are apt to attack the air passages.

Chemical Analysis.—The acid will have to be examined under the following heads:—1. Simple, concentrated acid. 2. Dilute acid. 3. Mixed with organic liquids, food, etc. 4. On the clothes of the person injured.

I. Concentrated Acid.

1. *Action on Organic Matter.*—The strong acid tinges most organic tissues, when immersed in it, a *yellow colour.* The stains on black cloth are at first distinctly *red*, becoming reddish-brown after a few days.

2. *Action on Metals.*—This acid does not act on copper or mercury, even when boiled with them, and this distinguishes it from the other acids.

3. Hydrochloric acid, added to peroxide of manganese and then warmed, gives off chlorine gas, detected by its greenish-yellow colour and suffocating odour. The vapour thus produced bleaches litmus paper, and causes a blue coloration on starch paper moistened with iodide of potassium.

II. Dilute Acid.

1. Decomposes alkaline carbonates, chlorides being formed, which, when heated in the solid state with strong sulphuric acid and peroxide of manganese, evolve chlorine gas, known by the before-mentioned tests.

2. *Precipitation of Chloride of Silver.*—A white curdled precipitate of chloride of silver is thrown down when a solution of nitrate of silver is added to hydrochloric acid. This pre-

cipitate becomes grey on exposure to light. If a portion of the precipitate be added to ammonia it will dissolve; another portion, when boiled with nitric acid, is unaffected; and a third portion, ignited in a capsule, becomes converted into a horny mass.

In any case where there is a doubt as to whether the hydrochloric acid exists in the free state, or is only present in the form of chlorides, the following test should be resorted to, which will not only discriminate between the two forms, but give the relative amount of each present:—

Take two equal measures of the acid liquid. Precipitate one with nitrate of silver, after the addition of nitric acid, and weigh the precipitate. Evaporate the second portion of the acid liquid to dryness, and dry the residue in a water bath; dissolve this residue in distilled water, and treat the solution with nitrate of silver as before, weighing any precipitate which occurs. The weight of chloride of silver obtained from the first portion of the liquid will give all the hydrochloric acid present, both in the free state and in combination; while the weight of the silver precipitate in the second portion of liquid only gives the chlorides, all free—hydrochloric acid having passed off during the process of evaporation.

III. Mixed with Organic Liquids, etc.

The suspected acid liquid should be filtered, and then distilled almost to a dryness. The portion of the distillate which comes over at first may be thrown away; but the latter portion will give all the reactions before described for hydrochloric acid, if that be present. Distillation is adopted in the case of this acid, as it is more volatile than either sulphuric or nitric acid. It may be objected that the acid found in the vomited matters is from the gastric juice. In answer to this, it may be stated that the free hydrochloric acid in normal gastric juice is only about five grains in sixteen ounces, an amount which would give but slight reaction with the tests.

IV. Stains on the Clothes, etc.

The spots produced by the action of the acid on black cloth are at first of a *bright red* colour, changing in ten or twelve days to reddish-brown. These spots may be cut out and

macerated in warm water; the liquid thus obtained then tested by nitrate of silver and the other tests before noticed. Another portion of the cloth should be treated in the same manner, and the resulting liquid tested, as a set-off against the objection that the acid was present in the cloth. Hydrochloric acid has been used to erase writing from paper in attempts at forgery, etc. The paper must be treated in the same manner as mentioned for the cloth, and the tests used. Sometimes oxalic acid is employed for a like purpose, in which case the nitrate of silver will give a precipitate; but the oxalate of silver is soluble in nitric acid; the chloride is not soluble even when boiled.

Fatal Period.—From two or five hours to thirty hours or more.

Fatal Dose.—One fluid drachm to one ounce; recovery has taken place after swallowing two fluid ounces.

Treatment.—The same as for the other acids.

TABLE SHOWING THE COLOUR PRODUCED BY THE ACTION OF THE MINERAL ACIDS ON THE SKIN AND ON CLOTH.

	SKIN.	CLOTH.
Nitric acid	Bright yellow, due to the formation of picric acid. Colour heightened by alkalies.	Yellow, orange-red, or brown.
Sulphuric acid . .	Brown colour.	Dirty-brown edges becoming red after a few days from absorption of moisture.
Hydrochloric acid . .	Greyish-white.	Bright red changing after some days to reddish-brown.

SULPHATE OF INDIGO.

A dark blue liquid formed by dissolving indigo in strong sulphuric acid. Used as a dye. The symptoms are much the same as those detailed under sulphuric acid, with the

additional bluing of the mouth and lips. It may be detected with the tests given under sulphuric acid, the blue colour being first discharged by boiling it with nitric acid.

CARBOLIC ACID.

Phenic Acid. Coal-tar Creasote. Oil of Tar.

Carbolic acid is obtained in the dry distillation of coal, and forms the acid portion of coal-tar oil, from which it is subsequently extracted by shaking the crude coal-tar oil with a mixture of slaked lime and water. After allowing the mixture to stand for some time, the watery portion is separated from the undissolved oil, the former treated with hydrochloric acid, and the resulting oily fluid purified by careful distillation. Up to the year 1900 no restrictions were put upon the sale of carbolic acid, but owing to the large number of suicidal and accidental deaths from its use, it was by Act of Parliament scheduled as a poison, and all preparations containing more than 10 per cent of it, cresylic acid or their homologues, must be sold as poisons.

Pure carbolic acid forms long, colourless, prismatic needles, which melt at 35° C. into an oily liquid. It boils at 180° C., and greatly resembles creasote, for which it is very frequently substituted in commerce, but from which it differs in the following characters: It does not affect polarised light as creasote does; it forms a jelly-like mass with collodion, and is soluble in a solution of potash, whereas creasote is unaffected by collodion, and is insoluble in a solution of potash. (Specific gravity, 1·065.). It possesses a penetrating, characteristic odour; burning taste; is slightly soluble in water, but freely so in glycerine, ether, and alcohol; and gives no acid reaction to test paper. When undiluted, it attacks the skin, which it shrivels up.

Creasote is obtained from wood-tar, to which it imparts its caustic properties.

Carbolic acid acts as a corrosive and anæsthetic on the skin and mucous membranes, and as a narcotic on the brain. Its poisonous properties are equally exerted whether it be swallowed or merely applied to the skin, especially if a wound be present.

Effects on the Skin, etc.—Strong carbolic acid, when applied to the skin, corrugates, hardens, and destroys its sensibility,

and is said to whiten it; though in one case, where the crude acid had been taken with a suicidal intent, there was after death a dark-brownish ring about half-an-inch wide surrounding the mouth; and in another, that of a child who, in climbing to a shelf, poured over its face and neck about half a saucerful of diluted acid, the colour of the skin touched by the acid was yellowish-white and yellowish-brown, dry and parchment-like. The action of the acid on the mucous membranes is similar to that on the skin, but the corrugation is more marked, and considerable softening and peeling may also take place.

Effects on the Nervous System.—Rapidly supervening stupor, total muscular relaxation, anæsthesia, and stertorous breathing, are among the most prominent symptoms. Nearly all the sufferers die comatose. Carbolic acid appears to act principally on the central nervous ganglia at the base of the brain and on the spinal cord. The evidence is more in favour of its action on the brain than on the spinal cord, and not at all on the periphery of the nerves. The muscles contract vigorously after death, in response to galvanic stimulation applied either to the nerves or to the muscles themselves.

Effects on the Circulation.—The action of carbolic acid on the circulation has not yet been fully worked out, but it appears to be a cardiac depressant, the heart being arrested in diastole.

General Symptoms.—As soon as the acid is swallowed, the patient complains of intense burning pain in the mouth, throat, and stomach, the pupils are contracted, the conjunctiva insensible to touch, the skin cold and clammy, the temperature rapidly falls, and the pulse becomes weaker and weaker, till it is almost imperceptible. The breathing is laboured, and, as the fatal issue approaches, becomes stertorous; vomiting of frothy mucus occurs in some cases. The invasion of the symptoms is most rapid, and many of the patients have been in an insensible condition when found. The above symptoms have even supervened when the strong acid has been used for dressing wounds.

Dr. J. Hamilton records a case where the acid was used as an application to a wound four inches long, in a child four and a half years of age. Direct contact of the acid with the wound was prevented. About an hour after the dressing was applied he saw the patient, who was then supposed to be suffering from

the effects of chloroform used during the operation on the child's arm. She was suffering from symptoms like those before described. On removing the dressing, some of the carbolic acid, it was found, had melted and run into the wound, and to this Dr. Hamilton attributed the symptoms. The child ultimately died. (See *British Medical Journal*, 1873, vol. i. p. 226.)

The urine and fæces, when passed, are of a dark colour, and it has been frequently noticed that the urine passed by the assistants in surgical hospitals, who, under the antiseptic methods adopted, are constantly washing their hands in solutions of carbolic acid, is of an olive-green colour. This shows that absorption takes place readily through the skin. Bilroth, in his work on *Clinical Surgery*, gives several instances of absorption in this way.

Post-mortem Appearances.—If the poison has been drunk, a dark-brownish horny rim may be found soon after death round the lips; the mucous membrane of the mouth and stomach is whitened, corrugated, and softened, and looks as if smeared with white lead,—in some cases, horny in patches; inflammatory signs being absent or only slightly visible. The blood is uniformly fluid, becoming a bright red on exposure. The smell of carbolic acid is detected in the stomach, and sometimes in the small intestine, and even in the spleen, liver, and kidneys. In Dr. Ferrier's case, the urine found in the bladder after death had a slight olive-greenish tint with a peculiar mixed odour, which gave the usual reactions to the tests for carbolic acid. The dark colour of the urine is not due to the presence of hæmin, as the urine, in poisoning by carbolic acid, does not contain more than a normal amount of iron; the colour is, therefore, probably due to some product formed by the partial oxidation of the acid. The left ventricle of the heart is, in most cases, found contracted, the right flaccid. The lungs are congested, and this may also be the case with the vessels of the brain; but there may be an entire absence of any *post-mortem signs* to point to the probable cause of death, where the poison has gained entrance through a wound when the acid has been used as a surgical dressing.

Chemical Analysis.—Carbolic acid may be separated from mixture with organic substances by distillation with dilute sulphuric acid, from urine by agitation with ether. Bromine

water, as recommended by Landolt, gives a bulky yellowish precipitate of tribromo-phenol. The precipitate should then be collected, well washed, and gently warmed in a test tube with sodium-amalgam and water. The liquid poured into a dish and acidulated, will, if phenol be present, give the characteristic odour of that substance, and may be seen floating in the liquid as an oily fluid. By this test, one part of phenol in 43,700 of water may be detected. It must be remembered that, according to Landolt, carbolic acid is normally present in the urine, but Hoppe Seyler contends that it is not originally present in urine, but is formed by the action of sulphuric acid, probably from indican. Carbolic acid urine, treated with nitric acid, and then with potassa, and concentrated, becomes blood-red, brown-red, and then changes from pea-green to violet. Carbolic acid mixed with urine does not give the above reactions (Schmidt's *Jahrbucher*, Bd. clxiv. p. 144).

A solution of carbolic acid, mixed with one-fourth of its volume of ammonia and a few drops of bleaching-powder solution (1 in 20 of water), and then warmed, but not boiled, assumes a blue colour (green in very dilute solutions), becoming red on the addition of sulphuric or hydrochloric acid. The perchloride of iron gives a violet colour with carbolic acid.

Fatal Period.—Death has occurred in three minutes; also delayed to sixty hours; usually three to four hours.

Fatal Dose.—One drachm has caused death in twelve hours. A child six months old died from the effects of a quarter of a teaspoonful of a solution of one part of the acid to five of glycerine. Recovery has taken place after an ounce of 90 per cent strength liquefied acid, also after four ounces of the crude acid; after six ounces of the crude acid, 14 per cent strength; and in a child of two after half an ounce of crude acid of 30 per cent strength.

Treatment.—Stomach pump. Wash out the stomach with equal quantities of alcohol and water mixed—whisky, brandy, gin or rum will do until absolute alcohol or rectified spirit be obtained. The washing should be repeated every 5 to 15 minutes from four to eight times; apomorphine hydrochlorate gr. $\frac{1}{10}$ should be given hypodermically at the commencement, and the administration of demulcent drinks. Emetics are of little or no use, owing to the anæsthesia of the mucous membrane of the stomach. The sulphate of soda, Glauber salts, has been

proposed as an antidote. Any soluble sulphate may be tried. Oil or vinegar is the best outward application to the skin, after washing with spirit of wine or methylated spirits.

OXALIC ACID.

This is a powerful corrosive and cardiac poison, but on account of its strongly acid taste it is ill-adapted for the purposes of the murderer. Deaths have not infrequently

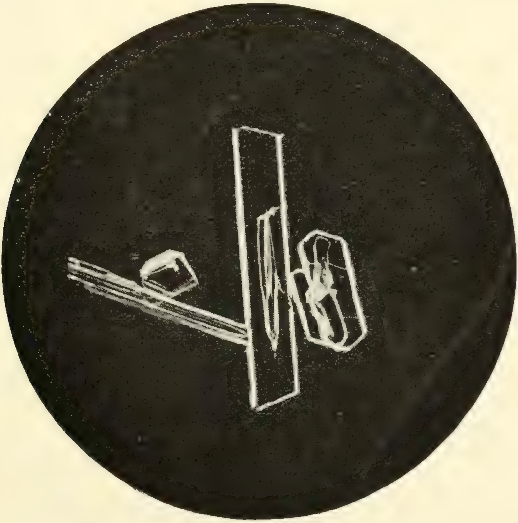


FIG. 23.—Photo-micrograph of crystals of oxalic acid, ×50. (R. J. M. Buchanan.)

followed the accidental substitution of this substance for Epsom salts—sulphate of magnesia—which it somewhat closely resembles.

The ordinary crystals of oxalic acid are in the form of four-sided prisms, colourless, transparent, odourless, or with a slight acid smell, very acid taste, and not deliquescent in the air. It is largely used in the arts, by brass-polishers, straw-bonnet makers, bookbinders, and others. The acid is also used to remove writing-ink from parchment, paper, etc., for the purposes of forgery, etc.

Symptoms.—These present many strange anomalies. In a large dose—an ounce or more—oxalic acid acts as a corrosive; in a smaller, as an irritant; and in a still smaller dose, as a cardiac sedative. Death has been known to occur so rapidly as to prevent any attempt at treatment. When the dose is large, an acid taste is experienced during swallowing, followed by burning pain in the throat and stomach. Vomiting then sets in, and in most cases continues till death, which may, however, occur when this symptom has existed from the first. The vomited matters may be simply mucus, mucus and blood, or dark coffee-grounds-looking matter. Unless the case is protracted, the bowels are rarely much affected, though purging and tenesmus have been noticed. Collapse now sets in; the pulse becomes feeble and scarcely perceptible, the skin cold and clammy, showing the action of the poison on the heart probably through the central nervous, as well as through the intra-cardiac, ganglia. Should the treatment adopted prove successful, and life be prolonged, the patient complains of tenderness of the mouth, soreness of the throat, and painful deglutition. Pressure over the abdomen causes pain. Vomiting and purging are also frequently present; and if recovery takes place, convalescence is generally very gradual.

Oxalic acid acts as a poison when applied to a wound in any part of the body; and although this substance undoubtedly acts on the brain through the medium of the blood, it is a remarkable fact that *it cannot be detected in that fluid*, even when injected into the femoral vein of an animal which died in thirty seconds (CHRISTISON) Leeches, it is recorded, have been poisoned by the blood drawn by them from persons suffering from oxalic-acid poisoning. The blood does not appear to undergo any physical change. Unlike the mineral acids, oxalic acid is still poisonous even when its corrosive and irritant properties have been destroyed by dilution.

Post-mortem Appearances.—The mucous membrane of the mouth, tongue, and throat is corrugated, white, and softened. The tongue is sometimes of a brownish colour, and sordes appear on the teeth. The stomach is in some cases pale, soft, and very brittle, and contains a dark, grumous, acid liquid; at other times it presents several semi-gelatinous spots, looking as if they had been boiled. Enlarged blood-vessels filled with dark-coloured blood are also seen ramifying over the internal

surface of the organ. Perforation is of rare occurrence. The intestines generally escape with some slight inflammatory redness, unless the case is unusually prolonged. In some cases the stomach is quite healthy, no morbid appearance being found in any portion of the alimentary canal.

Chemical Analysis.—From organic mixtures the acid may be separated by dialysis, and the tests applied, or it may be obtained in crystals by precipitating it from the boiled and

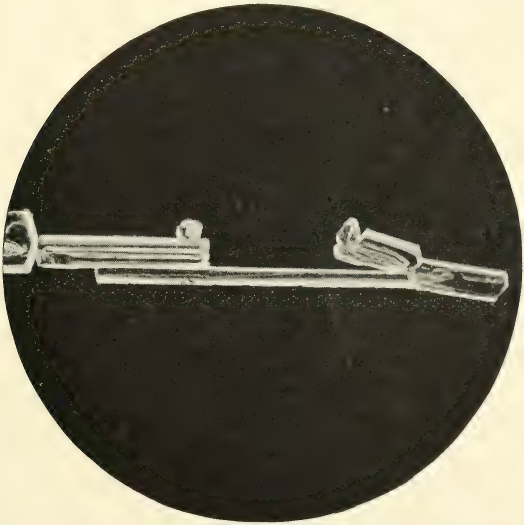


FIG. 24.—Photo-micrograph of crystals of oxalic acid, ×50. (R. J. M. Buchanan.)

filtered organic mixture with acetate of lead. The precipitate washed is then decomposed by sulphuretted hydrogen and filtered, the filtrate concentrated to drive off excess of sulphuretted hydrogen, and then set aside to crystallise, which, if the acid be present, it does in slender prisms. From the contents of the stomach the acid may be separated by partial drying over a water bath, extraction with hot alcohol acidulated with a little hydrochloric acid, filtering the alcoholic solution, evaporating to dryness and dissolving the residue in water. Should, owing to the treatment adopted, oxalate of

lime in white chalky masses be found in the stomach, these should be washed and then boiled with pure carbonate of potash. A partial decomposition takes place, insoluble carbonate of lime and soluble oxalate of potash are present in the liquid, which, when filtered and neutralised with nitric acid, may be tested with the following reagents :—

1. *Nitrate of silver* gives a white precipitate, *soluble* in *cold* nitric acid ; the precipitate dried and heated on platinum foil is dissipated in a white vapour with slight detonation.

2. *Calcium chloride or sulphate* produces a white precipitate with oxalic acid ; the test is more delicate if the acid be first neutralised with ammonia. The precipitate is immediately dissolved by hydrochloric or nitric acid, but not dissolved by oxalic, tartaric, acetic, or other vegetable acid. Lime water should not be used as a test, as it gives precipitates with other acids ; the sulphate largely diluted is not open to this objection.

3. *Lead acetate* gives a white precipitate soluble in nitric acid. On clothes, parchment, etc., the spot or spots must be well boiled, and the above tests applied to the solution. The stains may vary from a brownish-red to orange-red colour.

Fatal Dose.—Three drachms have caused death in one hour ; sixty grains caused the death of a boy sixteen years of age, but recoveries have been known to take place after an ounce and an ounce and a half had been swallowed.

Fatal Period.—Death has resulted in *ten minutes* from a dose of *one ounce.* The shortest period has been three minutes. The time varies with individuals, even when the same quantity is taken. In the case of two girls who each swallowed *an ounce* of oxalic acid, one died in *ten minutes* and the other in *thirty minutes.* Death usually takes place within from half an hour to an hour, although it has been delayed for five days.

Treatment.—Water should not be given, as it increases the solubility of the acid, and thus assists in the more extensive absorption and diffusion of the poison. The carbonates of potash and soda should be avoided, as the oxalates of these alkalies *are themselves* poisonous. The stomach tube should not be used. Lime is the best antidote, as the oxalate of lime is insoluble, and may be given in the form of common *whiting ;* a pint of saccharated lime water may be given. Vomiting should be promoted. In the stage of collapse the case must be treated on general principles.

Essential Salt of Lemons.

The binoxalate of potash or salt of sorrel, or, as it is more commonly known, salt of lemons, occurs as a constituent of many plants. The common sorrel—*Rumex Acetosa*—contains it in large quantities.

Symptoms.—Those of poisoning by oxalic acid, on which its poisonous properties depend.

Post-mortem Appearances.—Inflammation of the stomach and intestines. Other appearances as in oxalic acid.

Chemical Analysis.—See oxalic acid. The incinerated salt leaves a white residue of potassium carbonate; oxalic acid leaves no residue.

Fatal Period.—*Eight minutes* in the case of a lady recently confined, who took half an ounce of the salt by mistake for cream of tartar.

Fatal Dose.—Half an ounce.

Treatment.—The same as recommended for poisoning by oxalic acid.

ACETIC ACID.

In the glacial form this acid acts as a corrosive, the dilute acid as an irritant. Cases have been recorded of poisoning by the glacial acid.

Symptoms.—The parts with which the acid has come in contact are softened and rendered yellowish-white in colour. The larynx is commonly affected by the acid, as it is very volatile.

Post-mortem Appearances are those of corrosive poisoning with inflammatory action in the upper air-passages.

Fatal Period is variable but rapid.

Fatal Dose.—One drachm caused death in a child, but recovery has taken place in an adult after taking six fluid ounces.

Chemical Analysis.—Separate the free acid from organic matter by distillation, if in combination it should be liberated by adding phosphoric acid. With ferric chloride and ammonia to neutralisation a red colour is produced, turned yellow by hydrochloric acid.

Treatment.—Magnesia should be given to neutralise the acid and vomiting produced. The laryngeal symptoms will require treating on general principles; tracheotomy may be necessary.

TABLE SHOWING SYMPTOMS, POST-MORTEM APPEARANCES, FATAL DOSE, PERIOD OF DEATH, AND TREATMENT OF POISONING BY

	SULPHURIC ACID.	HYDROCYANIC ACID.	OXALIC ACID.
Symptoms . .	Burning pain in the mouth, throat, and gullet. Constant vomiting of brownish or blackish matter containing blood. The lips shrivelled, blistered, and excoriated; and the corners of the mouth show signs of the corrosive action of the poison. Collapse and death.	Giddiness, insensibility, difficult respiration, dilated pupil, tetanic spasms, and convulsions. In acute cases, death by shock; in those more prolonged, suffocation ends the scene.	Burning pain in the mouth and throat, vomiting of greenish-brown or grumous matter. Collapse sets in; skin cold and clammy; frequent pulse, and respiration hurried. Delirium and convulsions end in death. Effects depend on size of dose. Well diluted, it acts on brain, spine, and heart.
Post-mortem Appearances.	Presence of the signs of powerful corrosion; perforation of the stomach, which is blackened and softened.	Face pale and countenance composed; congestion of the brain, and traces of inflammation in the stomach and bowels. Odour of prussic acid may be detected in most cases in the stomach and other parts of the body.	Lining membrane of mouth and fauces white, shrivelled, and easily removed. Perforation of stomach rare. The *post-mortem* appearances depend on dilution of acid.
Fatal Dose . .	One drachm.	About 45 minims of the Pharmacopœia acid.	One drachm in a boy; in another case, half an ounce.
Fatal Period . .	One hour. Average about ten hours.	Two to five minutes.	Less than ten minutes.
Treatment . .	Magnesia, chalk, whiting, soap suds, milk, and mucilaginous drinks.	Chlorine in vapour and in water, and the mixed oxides of iron. Cold affusion to the head and face, galvanism, artificial respiration, etc.	Chalk and water. Promote vomiting. Magnesia, lime water, and oil. Mucilaginous drinks.

THE ALKALIES.

POTASH. SODA. AMMONIA.

Poisoning by the use of the alkalies is very rare. For the sake of convenience, and as the symptoms produced by the caustic preparations of soda and potash, taken in large doses, do not greatly differ, one description will do for both :—

Potash is found in commerce as—(1) Caustic potash, either solid or in solution. (2) Carbonate and bicarbonate. (3) Pearl-ash and soap-lees.

Soda is found as—(1) Caustic soda. (2) Carbonate and bicarbonate. (3) Soap-lees, carbonate of soda mixed with caustic alkali.

General Characters.—Like the inorganic acids, the alkalies destroy the animal tissues with which they come in contact. Their action is local, no specific remote effects being produced. They are seldom, if ever, used for the purpose of homicide; the deaths caused by them are in most cases the result of accident or suicide. When injected directly into the veins of animals, the toxic action of potash and soda appears to differ, the former arresting the action of the heart in diastole, whereas the latter, according to Podocaepow and Guttman, does not, even in large doses, affect the heart or temperature—Guttman, moreover, asserting that soda has no influence upon the nerve centres, the peripheral nerves, or the muscles. It is difficult to understand how, with this asserted negative action, soda, like potash, causes death.

Symptoms.—During the act of swallowing, the patient complains of a caustic taste, accompanied with a sensation of burning in the mouth and throat, extending into the stomach. Vomiting may or may not be present; but in severe cases, when it does occur, the vomited matters may be mixed with blood. The surface of the body is cold, and bathed in a cold sweat. Purging is generally present, accompanied with intense pain and straining. The pulse is weak and quick, and the countenance anxious.

The *post-mortem* appearances are inflammation and softening of the mucous membrane of the mouth, gullet, and stomach, which may also be covered with chocolate or black-coloured spots. Where life has been prolonged for some months the

stomach may become contracted, the pyloric orifice scarcely admitting the passage of a fine probe.

Chemical Analysis.—The caustic alkalies are known from their carbonates, by giving a brown precipitate with nitrate of silver; whereas their carbonates give a white, and also effervesce on the addition of an acid.

The following Table will show the reaction of these alkalies with reagents:—

To distinguish Caustic Potash from Caustic Soda.

	Potash.	Soda.
Bichloride of platinum .	A canary-coloured precipitate in solutions acidulated with hydrochloric acid.	No precipitate.
Strong solution of tartaric acid.	Precipitate in granular white crystals.	No precipitate.
Colour given to flame .	Rose or lilac tint.	Yellow tint.
Neutralised with nitric acid.	Crystallises in long, slender, fluted prisms.	Crystallises in rhombic plates.

In Organic Mixtures.—If the mixture be strongly alkaline, filter and test as above.

Fatal Period.—From three hours to as many years.

Fatal Dose.—About half an ounce of the caustic alkali. The smallest fatal dose recorded of caustic potash is forty grains.

Treatment.—Water freely; drinks containing citric or acetic acid, vinegar, lemon juice, oil, linseed tea, and other demulcent drinks. The stomach tube should be avoided.

AMMONIA.

In vapour, in solution, or solid.

Symptoms.—The vapour may cause death by producing inflammation of the larynx and lungs. The symptoms to which it gives rise are a feeling of choking, and a suspension of the power of breathing. Intense heat and pain are felt in the throat, which may remain for some time. When ammonia is

swallowed in solution, the symptoms produced are not unlike those the result of the action of soda or potash, only more intense. Dr. Patterson records the history of a case of a poor man who drank about an ounce of the liquid ammonia. When seen, his lips were livid, breathing stridulous, aspect anxious, extremities cold, pulse 100; inside of mouth, tongue, fauces, as far as visible, red, raw, and fiery-looking. He died suddenly, nineteen days after the accident, of laryngismus stridulus. Albuminuria occurred in one case.

The *post-mortem* appearances are those found in most cases of poisoning by corrosives.

Chemical Analysis.—Ammonia can be separated from organic mixture by distillation. Putrefaction must not have taken place. The vapour of ammonia is easily set free and recognised by its pungent odour. The carbonate effervesces when an acid is added to it, and gives a white precipitate with salts of lime. Dense white fumes are given off in the presence of hydrochloric acid. Nessler's reagent gives a reddish-brown colour or precipitate.

Fatal Period.—Death has been known to occur in *four minutes*, but life may be prolonged for some time, the person dying of some thoracic trouble.

Fatal Dose.—A teaspoonful of the strong solution.

Treatment.—Vinegar and water, lime-juice and oil, and leeches to the throat if the inflammatory symptoms be severe. The rest of the treatment will depend upon the symptoms present. Tracheotomy may be necessary.

CAUSTIC SALTS.

CHLORIDE OF ANTIMONY.

Chloride of antimony (butter of antimony) is a corrosive liquid. The colour varies from a light yellow to a dark red. Though a powerful poison, it is seldom taken for that purpose. It has been taken by mistake for ginger beer. On the addition of water, the white oxychloride is precipitated.

Symptoms.—The symptoms produced by swallowing this substance are those of corrosive poisoning. The mouth and throat are excoriated, the skin cold and clammy, and the pulse

feeble and quick. Severe pain is felt in the stomach, and vomiting is incessant.

Post-mortem Appearances.—Those found after corrosive poisoning.

Chemical Analysis.—When poured into water, the chloride is precipitated; the precipitate, soluble in tartaric acid, becomes orange-red on the addition of hydrogen sulphide. The supernatant liquid will give a white precipitate with nitrate of silver, showing the presence of hydrochloric acid. The salts of bismuth are precipitated by the addition of water, but the precipitate is, unlike the antimonial, insoluble in tartaric acid, and is blackened by hydrogen sulphide.

From *organic* liquids, the antimony may be obtained by boiling them with tartaric acid, filtering, and then applying the tests for antimony.

Treatment.—Milk, magnesia, and infusions containing tannin.

CHLORIDE OF ZINC.

This substance is a powerful corrosive. It is employed as a disinfectant, and is sold to the public under the name of "Sir W. Burnett's Fluid." This preparation, which is a strong solution of the chloride of zinc, has caused death by being mistaken for "fluid magnesia," for "pale ale," and in one case, on board one of the American steamers, for "mineral water." Chloride of zinc is also used in the treatment of cancer and other tumours as an external application.

Symptoms.—The symptoms come on immediately after the poison is swallowed. Chloride of zinc acts as a powerful corrosive, accompanied with all the symptoms which have been before described when speaking under the head of corrosive poisons. The nervous system is also powerfully affected.

Post-mortem Appearances.—Those of corrosive poisoning in its most violent form. The mouth, throat, stomach, and intestines are often found hardened, white, opaque, and corrugated.

Chemical Analysis.—Ammonium sulphide gives a white precipitate, which is insoluble in caustic alkalies. Hydrogen sulphide gives a white precipitate in neutral solutions, but no precipitate when the free mineral acids are present. Potassium

ferro-cyanide gives a white precipitate. Test for chlorine with nitrate of silver.

Treatment.—White of eggs, emetics, followed by demulcent drinks.

CHLORIDES OF TIN.

This metal requires but little notice; but the two chlorides—protochloride and the perchloride—form a mixture used in the arts, and known as *Dyer's Mixture.* They act as irritant poisons, but are seldom used as such.

NITRATE OF SILVER.

The only preparation of silver requiring notice is the nitrate—*lunar caustic*, or *lapis infernalis.* It acts as a powerful corrosive. If administered for some time in small doses it is deposited in the skin, which acquires a permanent dark colour. It does not appear to be eliminated by the urine, and has been discovered in the liver five months after its administration was discontinued.

The symptoms come on immediately; the vomited matters becoming blackened on exposure to light. The dark spots on the skin will also help to point to the nature of the poison. A dose of salt and water may be given by way of treatment.

VULNERANT.

GLASS, ENAMEL, AND NEEDLES.

None of the above can be considered as poisons; but should they be taken, they give rise in most cases to irritation of the stomach and bowels. Pins and needles have been swallowed without doing much harm. Mixing ground-glass in food is a favourite mode of killing adopted by the West Indian negroes.

CHAPTER III.

DIVISION II.—VITAL.

METALLOID IRRITANTS.

PHOSPHORUS.

Poisoning by this substance is more common in France than in England. In England, the deaths due to this poison are more frequently the result of accident, from the incautious use of phosphorus paste for the destruction of vermin. These pastes generally contain from three to four per cent of phosphorus. Children have also been poisoned by sucking the heads of lucifer matches. In one case, that of a child, death followed from sucking about forty matches. It has most frequently been employed as a means of suicide, but seldom for the purpose of homicide. One case, however, occurred at the Bodmin Assizes in 1857. Kopf relates a case of a young woman, aged twenty-four, who died on the fourth day after swallowing the heads of six packets of lucifers (*Allg. Wien. Med. Ztg.*, No. 47, 1819; Schmidt, vol. cv. p. 296). The size of the packets is not stated. In this case the bowels were confined, and the *post-mortem* revealed only the redness of inflammation in the stomach and bowels. Death has followed inunction of phosphorus paste.

General Characters.—There are two kinds—ordinary waxy, crystalline phosphorus, and a peculiar form known as red allotropic or amorphous phosphorus, prepared by heating waxy phosphorus to a temperature of 240° C., in an atmosphere free from oxygen. The ordinary yellow phosphorus is poisonous, the red or amorphous non-poisonous. As found in the shops, phosphorus is preserved in water in the form of translucent white or slightly yellow-coloured cylinders. It is

sparingly soluble in oil, alcohol, and other hydro-carbons, but greatly so in bisulphide of carbon. White vapours are given off when it is exposed to the air, these consisting of phosphorous and phosphoric acids.

Symptoms.—Phosphorus acts as an irritant poison, but some days may elapse after the poison is taken before the injurious effects become apparent. The symptoms occur in three stages.

First stage : The patient complains of a garlic-like taste in the mouth, peculiar to poisoning by this substance. This is followed by a burning sensation in the throat, accompanied with severe pain in the stomach, and intense thirst. The belly becomes swollen, and there is vomiting, in some cases, of blood from the stomach, which may continue till death. The vomited matters are of a dark green or black colour, with an odour of garlic, and sometimes appearing phosphorescent in the dark. This condition may also be observed in the motions passed. There is intense thirst. The pulse is feeble, the countenance anxious, and the surface of the body bathed in a cold sweat. In males, priapism is not infrequent. The nervous and muscular debility is intense, and the patient may die in a state of collapse or during a fit of convulsions.

Second stage : This is a stage of intermission of the symptoms which may last for three days or more, the patient seems as if going to recover, and only suffers from general malaise. A case is recorded where the intermission lasted nine weeks. In cases proceeding to a fatal termination the intermission is followed by the third stage.

Third stage : Jaundice is the most notable symptom and rapidly increases; the liver becomes much enlarged and the abdomen distended; epigastric pain is severe and there is vomiting of grumous black material consisting of altered blood; purging may be present and the motions contain blood. There is a marked tendency for hæmorrhages to occur from the mucous membranes and subcutaneously producing purpuric spots. The urine is diminished, high coloured, contains bile pigments, albumen, blood and casts. There are great prostration, a quick weak pulse, sleeplessness, coldness of the surface, gradually increasing weakness, apathy, convulsions and coma, followed by death about the fifth or sixth day.

The liver may diminish in size before death. It is rare for recovery to take place after enlargement of the liver and

jaundice have supervened. It is by no means always easy to diagnose acute yellow atrophy of the liver or malignant jaundice from phosphorus poisoning. In phosphorus poisoning, the early symptoms, those of acute gastritis, are more severe, are developed more rapidly, and run their course more quickly than in acute atrophy, and there is a marked interval between these and the appearance of the jaundice; in acute yellow atrophy this interval is wanting, and from the beginning, on the contrary, there are gradual malaise, slight gastric catarrh, and jaundice. The jaundice and suffering, together with the increased action of the heart in phosphorus poisoning, are wanting in malignant jaundice, but the cerebral symptoms are more marked in the latter than in the former. Acute yellow atrophy most frequently occurs in women, especially during pregnancy. In acute atrophy leucin and tyrosin are present in the urine; in phosphorus poisoning they may occur, but generally in the urine voided just before death.

Chronic poisoning, accompanied with all the symptoms just mentioned, may result from the action of the vapour on those engaged in the manufacture of phosphorus or of lucifer matches. In persons thus employed, necrosis of the jaws and caries of the teeth are not of infrequent occurrence. The lower jaw is more commonly affected. Mr. Lyons states that this form of necrosis cannot attack persons who have perfectly sound teeth, but only those whose teeth are carious (St. Bartholomew's Hospital Report, vol. xii.).

Post-mortem Appearances.—Those of acute irritant poisoning, including extensive destruction of the coats of the stomach, by softening, ulceration, and perforation, terminating in gangrene. The stomach may contain a quantity of white vapour, having a strong smell of garlic. This white vapour has been noticed to pass from the vagina and anus of those poisoned by phosphorus. The blood appears to be thoroughly disorganised; the blood-cells are colourless and transparent, their colouring matter being dissolved in the uncoagulated liquor sanguinis; hæmorrhages may be present beneath the serous membranes and in the pleural and pericardial cavities, and thromboses are frequently present, due to tendency for the blood-cells to agglutinate. In a case recorded in the *British Medical Journal*, 1873, fatty degeneration of the liver and kidneys was found a week after the poison was taken. In phosphorus poisoning,

the liver is enlarged, of a dull appearance, doughy, uniformly yellow, with the acini well marked; in acute atrophy, the liver is diminished in size, greasy on the surface, leathery, of a dirty-yellow colour, with traces only of the obliterated acini. In the former, also, the hepatic cells are either filled with oil globules or entirely replaced by them; in the latter, the cells are filled with a fine granular detritus, and their structure replaced by newly-formed connective tissue. Putrefaction rapidly supervenes on death. Hæmorrhages may be found on the surface of the brain and spinal cord, and the grey matter of the cortex and basal ganglia rose-pink in colour. Fatty changes have been found in the walls of the capillaries and the large cortical cells.

Chemical Analysis.—The smell of phosphorus is characteristic, as is also its luminosity when exposed in the dark. The following process, suggested by Mitscherlich, may be adopted for its detection:—

To render the suspected matter quite fluid water is added, previously acidulated with sulphuric acid, in order to neutralise any ammonia present. The liquid is then transferred to a glass retort, fitted with a long condensing tube passing into a receiver containing solution of nitrate of silver. Distillation is conducted in the dark, when the minutest trace of phosphorus may be detected by the luminous appearance of the vapour during condensation. Other modifications of this process have been suggested, in order to increase the space occupied by the phosphorescence.

By the above process, one part of phosphorus may be detected in 100,000 parts of substance. Another method for the detection of this poison in very minute quantities is that proposed by Dussart (*Compt. Rend.*, xliii. 1126), and modified by Blondlot (*Compt. Rend.*, lii. 1197). The test is based on the fact that when phosphorus is exposed to the action of *nascent hydrogen* in a Marsh's apparatus, it burns with an emerald-green flame. In order to avoid the yellow colouring of the flame produced by the sodium in glass, Blondlot recommends the use of a platinum jet. As the green colour is more or less interfered with by the presence of organic matters, he passes the gas through a solution of nitrate of silver; the resulting precipitate is then placed in another hydrogen apparatus, as just mentioned, and the colour of the flame of

the issuing gas noted. Phosphorus may become decomposed in the body; and as phosphoric acid is taken in most articles of food, the only satisfactory evidence of phosphorus having been taken is to produce it in its free state, or at least to exhibit its luminosity. The detection of the colouring matter of lucifer matches in the stomach or vomited matters will point to the probable nature of the poison, and whence it was derived.

Scherer's Test is based on the reducing action of phosphorus on nitrate of silver, which it blackens. The suspected material should be placed in a flask or in a Dowzard's apparatus for Gutzeit's test for arsenic, lead acetate is added to the material to fix the H_2S and some lead acetate solution placed in each cell. A little ether is added to the mixture, and the flask or top of the apparatus capped with paper moistened with nitrate of silver, and set aside for some hours in a dark place. If phosphorus be present the paper will be blackened from deposition of metallic silver.

Fatal Period.—From half an hour to twenty days or more.

Fatal Dose.—One grain and a half. The smallest fatal dose recorded for an adult is one-eighth of a grain. An infant five weeks old died from sucking a single match head, which probably contained one-fiftieth of a grain of phosphorus. Recovery has taken place after four and six grains have been taken.

Treatment.—The stomach pump or syphon tube should be used as soon as possible, and the stomach well washed out with warm water containing a drachm of old oil of turpentine to the pint. If the turpentine be not readily obtained, "sanitas" should be used with the water, or a 1 per cent solution of permanganate of potash. After washing the stomach, the old oil of turpentine, or the French oil of turpentine, or sanitas may be administered in half- to one-drachm doses in mucilage and water every fifteen minutes for several doses, and afterwards three or four times daily. The 1 per cent solution of potassium permanganate may be administered in copious drinks.

According to some observers, turpentine is said to be of no value; but this failure in the use of turpentine has been shown to be due to the employment of different varieties of oil. The crude acid French oil, of the three kinds met with in commerce, appears to be the only one that acts as described below. With turpentine, phosphorus forms a spermaceti-like mass consisting

of *turpentine phosphorous acid.* It has an acid reaction, and is converted, on exposure to the air, into a resinous substance smelling like pine-rosin. With earths and metallic oxides it forms insoluble salts. The acid is not poisonous; doses of 0·03 to 0·3 gram. may be given to dogs and rabbits without any other effect than that of lowering of the bodily temperature. To the formation of this compound, the antidotal properties of turpentine in phosphorus poisoning are attributed (*Kohler a. Schempf Dingl.*, pol. Jcxcix.). Turpentine is said by some to be valueless if not given within twelve hours. Emetics of sulphate of copper may be administered, but the salt is liable to cause severe gastro-enteritis. Further treatment may consist of mucilaginous drinks containing magnesia and opium to relieve pain. Oils or fats should not be given because of their solvent action upon phosphorus.

Synopsis of the Effects due to Poisoning by Phosphorus.

1. Which variety of phosphorus is poisonous?—The ordinary yellow phosphorus usually kept in water. The allotropic form is inert.
2. What quantity is sufficient to kill an adult?—One grain and a half.
3. Symptoms as regards—
   (1) *Alimentary Canal.*—Pain in the stomach and belly, eructation of gas smelling like garlic, vomiting, and sometimes purging, with other signs of irritation.
   (2) *Circulatory System.*—Tendency to hæmorrhage from the mouth, stomach, lungs, bladder, etc. Petechiæ and ecchymoses may occur on all parts of the body. If the case be prolonged, anæmia may be present. Pulse small, weak, and scarcely perceptible.
   (3) *Nervous System.*—Cramps, creeping sensations in the limbs, delirium, convulsions, paralysis, and extreme nervous prostration.
   (4) *Period of Invasion of the Symptoms.*—Obscure and insidious; some hours or even days may elapse before the appearance of the symptoms.
   (5) *Period of Fatal Termination.*—In some cases as short as four hours.
4. *Post-mortem* Appearances—
   (1) *Alimentary Canal.*—Signs of irritation and inflammation in the stomach and intestines. Gangrene and perforation have been noticed. Strong smell of garlic when the abdomen is laid open. Appearances not unlike scurvy may be found.
   (2) *Cellular Tissue.*—Ecchymosis may be present in the cellular tissue of the abdomen, chest, and other parts of the body.
   (3) *Muscular Tissue.*—Fatty degeneration in the heart and other organs of the body has been noticed in several cases.
   (4) *Liver.*—Fatty degeneration of the gland.
   (5) Blood entirely disorganised, the cells transparent, and their

contents dissolved in the uncoagulated liquor sanguinis. The colour, cherry-red.

5. *Name* special affection produced by phosphorus in lucifer match makers—Necrosis of the jaws, usually of the lower jaw. The disease begins in a decayed tooth.

6. *Name* a natural disease which phosphorus poisoning has been supposed to resemble.—Acute yellow atrophy of the liver.

IODINE.

Iodine is seldom used as a poison, owing to the difficulty experienced in disguising its colour. In the form of a strong solution it has been, however, employed for throwing on the person with intent to cause grievous bodily harm, as in this form it is corrosive, and destroys the part which it touches.

General Characters.—Iodine is a dark grey solid, with a bright metallic lustre. It melts at 107° F., boils at 175° F., and gives off at the ordinary temperature a faint odour not unlike chlorine. But slightly soluble in pure water, it is, however, readily dissolved when a soluble iodide is added to the water.

Symptoms.—Those produced by irritant poisons generally; the severity of the symptoms being increased by the strength of the solution, iodine possessing corrosive as well as irritant properties. The vomited matter will be stained with the iodine, and starchy material turned blue or black.

Post-mortem Appearances.—Those the result of acute irritant poisoning.

Fatal Period.—Two days.

Fatal Dose.—One fluid drachm of the tincture has proved fatal; recovery has taken place after taking one fluid ounce of the tincture.

Treatment.—The stomach should be emptied by the aid of the stomach pump, and then diluent drinks—arrowroot and barley water—may be given.

Chemical Analysis.—Add bisulphide of carbon to the suspected mixture, and shake them together. The sulphide will dissolve out the iodine, which may be obtained on evaporation and sublimed. The characteristic reaction of iodine, the development of a blue colour on the addition of a small quantity of starch, will be conclusive evidence of its presence. If chloroform be added to iodine in aqueous solution and shaken up, the chloroform is coloured crimson by the iodine, and falls to the bottom as the mixture is allowed to settle.

IODIDE OF POTASSIUM.

This salt is largely used in medicine ; and though poisonous effects may be produced, due probably to some constitutional idiosyncrasy, it has seldom been used as a poison. It must, however, be placed among noxious irritant substances.

General Characters.—Iodide of potassium—hydriodate of potash—occurs in cubical crystals of a white or faint yellow colour, very slightly deliquescent when pure, and with a feeble odour of iodine.

Symptoms.—Iodide of potassium acts as an irritant in large doses, producing also many of the symptoms which attend a violent catarrh. Small doses—three to five grains—have produced in some persons most unpleasant and even alarming symptoms. In chronic poisoning, certain glands, the mammary and testicles, are said to waste away. Salivation is not infrequently present. (See the account in *British Medical Journal*, 1878, of a case of purpura in a child five months old, after a dose of two and a half grains of the salt.)

Treatment.—The use of emetics and the stomach pump, starch, etc.

Chemical Analysis.—In solution, iodide of potash gives the following characteristic reactions :—

1. With a salt of lead . . .	Bright yellow precipitate.
2. With corrosive sublimate . .	Bright scarlet precipitate.
3. With strong nitric acid and starch	A blue colour.

In organic mixtures the mode of detecting it is more complicated.

Sulphuretted hydrogen should be first passed through the mixture in order to convert any free iodine into hydriodic acid. The excess of the gas is then driven off by the application of heat, and potash added, the resulting liquor filtered, and the filtrate evaporated to dryness. To get rid of any organic matter, the residue left after evaporation is charred at a low red heat, reduced to powder, and dissolved in water. This solution is then concentrated, and strong nitric acid and solution of starch added, when, if iodine be present, the blue colour will be developed.

CHAPTER IV.

METALLIC IRRITANTS.

ARSENIC.

Arsenic is found as metallic arsenic, as arsenious acid, in the form of two sulphides—realgar and orpiment, and as a constituent of several ores—iron, copper, etc.

Metallic arsenic is of a steel-grey colour, brittle, and sublimes at a temperature a little below 400° F., without, however, previously fusing. The vapour of the metal has a peculiar garlic-like odour, which is not possessed by any of its compounds.

Arsenious Acid.

Arsenious acid—white arsenic—the most important of all the compounds of arsenic, is colourless, odourless, and almost devoid of taste. As found in commerce, it occurs under two forms—as a white powder, and as a solid cake, which is at first nearly transparent, but soon becomes opaque, and then resembles white enamel. At a temperature of about 380° F. it sublimes, but is again deposited on cool surfaces in the form of octahedral crystals. It is but slightly soluble in cold water, only about half a grain to a grain being taken up by an ounce of water. Stirred in boiling water, and then allowed to cool, from a grain to a grain and a quarter is dissolved in the same quantity of water; but when it is boiled for an hour, about twelve grains are dissolved in the ounce of water. This solubility is, however, diminished by the presence of any organic matter in the liquid. It is therefore less soluble in infusions of tea or coffee than in pure water. A teaspoonful of powdered arsenic is said to weigh 150 grains, and a pinch 17 grains.

Arsenious acid is used in the arts in the manufacture of

certain green colours, in dyeing, and in calico printing. A weak solution is employed in medicine; in the treatment of certain diseases of the skin, in ague, and in other diseases.

It has been proposed to use arsenious acid, on account of its caustic properties, as an application for cancerous tumours. The employment of this substance for this purpose is by no means new; but its use has been revived from time to time by the charlatan. In the year 1844, a man was tried at the Chester Winter Sessions (R. *v.* Port) for the murder of a woman whom he pretended to cure of a cancer by the use of an arsenical plaster. In another case, recorded by M. Flandin, where death occurred, the quack declared that he had not applied more than *four* or *five* grains to the woman's breast. The powder used by these gentlemen is generally composed of arsenious acid, realgar, and oxide of iron. The above cases, to which many more might be added, attest to the danger which attends the application of arsenic to the surface of the body; it should, therefore, never be used, especially as a more safe and potent caustic for this purpose is found in the chloride of zinc. Some years ago, in London, several cases of severe arsenical poisoning were due to the presence of arsenic in some cheap violet powder. In one case the navel and scrotum of a baby were fearfully excoriated, due to the use of this powder.

Farmers employ arsenious acid (white arsenic) for destroying vermin: for steeping corn in order to destroy any spores of fungi; and it also forms an ingredient in the wash for sheep. Injurious effects have followed the accidental use of the corn thus treated, and those employed in washing the sheep have suffered more or less severely.

By an Act of Parliament (14 Vict. cap. xiii. sec. 3), it is ordered that if sold in small quantities, it must be mixed with the sixteenth part of its weight of soot, or the thirty-second part of its weight of indigo, ten pounds being the smallest quantity allowed to be sold unmixed.

The presence of this admixture must be remembered, as a medical man may be led into an error when the vomited matters are coloured blue, black, or green, from the mixture of bile with the indigo. Arsenic is not, as a rule, a corrosive poison, nor does it act chemically on the animal tissues. One case is, however, on record where it acted as a corrosive, but the purity of the arsenic in that case has been questioned.

Its action is that of an irritant, causing inflammation in the stomach and bowels of those who have taken it; and it appears that fatal effects are produced whether the poison be swallowed or introduced into the system in any other way—*i.e.* by injection into the rectum or vagina, or applied to the surface of the body.

Some observers hold that arsenic cannot be considered in the light of an accumulative poison, others that it is so to a certain extent, and that its elimination is not so rapid as was previously thought. Given in medicinal doses, it is eliminated in from fifteen to twenty days. Hence, in cases which have survived the immediate action of the drug, no arsenic may be found in the body fifteen days after its fatal administration. This is a fact of considerable importance. In the case of Pierre Emile L'Angelier, for whose murder Madeline Smith was tried, Dr. Penny found 88 grains in the stomach, although the deceased survived eight or ten hours after the probable period of taking the poison, and vomited repeatedly during that time. At the above trial, the question was suddenly started, that if such a large quantity was found after death in the stomach, it was scarcely possible to infer the administration of a much larger quantity; and thus that the quantity must have been larger than another party could have secretly administered, or naturally would attempt to administer. Drs. Mackinlay and Wylie, of Paisley, obtained 60 grains, and Sir R. Christison 30 grains more, from the stomach of a man poisoned by arsenic administered in whisky-punch sweetened, and the arsenic kept in suspension by constant stirring.

Symptoms of Arsenical Poisoning.

Acute.—The rapidity and virulence of the symptoms are more or less modified by the form (*i.e.* solution) and the quantity of the dose taken. From half an hour to an hour is the usual time which elapses before the symptoms of poisoning present themselves. In one case, when the poison was in solution, the symptoms came on immediately after it was swallowed; in another, after the lapse of ten hours. The patient first complains of a feeling of faintness and depression, followed by intense burning pain in the stomach, increased by the slightest pressure. Nausea and vomiting, the latter increased by the act of swallowing, now occur. The vomited matters may be dark brown, black, or bilious; or they may be

greenish from the indigo mixed with the arsenic coming in contact with the yellow colouring matter of the bile. Blood may also be vomited. Purging, accompanied with straining at stool, and cramps in the calves of the legs may occur—the purging, like the vomiting, being incessant, and affording no relief to the sufferer ; the stools may contain blood, or resemble those of cholera. The thirst is intense, and there may be a feeling of throat irritation, the pulse feeble and irregular, and the skin cold and clammy. The urine may or may not be suppressed. As a rule, the symptoms in this form of poisoning are *continuous ;* but cases occur in which there are distinct *remissions*, and even *intermissions*. Coma, paralysis, or tetanic convulsions may supervene before death closes the scene.

Certain anomalies may occur.—The pain may be absent or but slight. Vomiting and purging do not occur in all cases, nor is thirst, a most common and persistent symptom, always present. In some cases the symptoms resemble those which accompany an attack of cholera. In others, signs of collapse first make their appearance, from which the patient may rally, or he may die outright. These variations in the symptoms do not appear to be due to the *form* or *quantity* of the poison taken. It should also be remembered that arsenic may produce symptoms closely resembling those the result of *narcotic poisoning.*

Chronic.—In whatever way the poison be exhibited in small and repeated doses, there follows a peculiar and characteristic train of symptoms, associated with (*a*) the general nutrition of the body, (*b*) the facial appearance, (*c*) irritative disturbance of the alimentary canal, (*d*) skin eruptions, and (*e*) implication of the nervous system.

(*a*) The nutrition of the body is altered, there is gradual loss of flesh with ragged growth of the finger-nails and falling out of the hair. There may be œdema and jaundice in some cases.

(*b*) The face presents a peculiar appearance, the eyes are inflamed and watery, the conjunctivæ reddened and congested, there is excessive secretion from the nose resembling coryza.

(*c*) The disturbance of the digestive organs is revealed by the dryness of the mouth and occasional excoriation of the tongue, which may be reddened or covered with white fur and silvery in appearance ; salivation may be present instead of dryness of the mouth ; there may also be irritation of the

throat; symptoms of gastro-enteritis, *e.g.* nausea and vomiting, anorexia, diarrhœa, or alternating diarrhœa and constipation.

(*d*) The skin eruptions are of various kinds, and comprise eczema, herpes, urticaria, erythema, keratosis, marked pigmentation and exfoliation.

(*e*) The nervous symptoms are those of peripheral neuritis, numbness, formication, hyperæsthesia and tenderness, especially of the soles of the feet, the latter presenting appearances of erythromelalgia; there is some amount of paresis, in some cases amounting to absolute paralysis of the limbs affected. The hands may be anæsthetic, while the feet are hyperæsthetic and hyperalgetic, and the perspiration much increased. Mental symptoms are not common, but there may be hebetude, or delusions.

In the Maybrick case, tried at the Liverpool Assizes in 1889, the following symptoms arose from repeated administration of arsenic during a period of probably about fourteen days. On April 27 Mr. Maybrick was seized with vomiting after taking tea. On the next day the vomiting continued, with foulness of the tongue, and he complained of stiffness in the lower limbs. On May 1 he complained of feeling unwell after taking luncheon, and he was sick on the following three days, and complained of a tickling sensation in the throat, with retching. On May 7 he was still suffering from vomiting, diarrhœa had commenced, and the throat was very dry and inflamed. On May 8 the diarrhœa was accompanied by tenesmus. On May 9 the tenesmus was distressing, and he died on May 11.

Dr. Prosper de Pietra Santa describes a disease to which workers in manufactories of paper coloured with Schweinfurt-green are liable, characterised by the appearance of vesicles, pustules, *plaques muqueuses*, and ulcerations on the exposed parts of the body, fingers, toes, and scrotum. Arsenical poisoning has been mistaken for nettle-rash, scarlet fever, and Addison's disease. In cases of slow poisoning the symptoms resemble very much those of gastritis and ulcer of the stomach, and death due to the action of arsenic has been referred to "spontaneous inflammation of the bowels."

It must be remembered that in some cases of acute arsenical poisoning, when the acute symptoms have passed away, the nervous system exhibits its effects at a later period; in one case paresis came on on the fifth day, in another at the end of a week,

and in a case recorded by Seeligmüller four weeks elapsed before the onset of nervous symptoms.

Post-mortem Appearances.—The appearances found after death depend upon the quantity of the dose and the length of time which supervenes between the taking of the poison and death. Inflammation of the stomach is a marked effect of the action of this substance on the system; and this condition is in most cases present whether the poison be swallowed, sprinkled on an ulcerated surface, or rubbed into the skin. The inflammatory redness, which may assume the appearance of *crimson velvet*, may be found in cases where death has taken place in *two* hours. It is sometimes found spreading over the entire surface of the stomach; at others, at the cardiac end only. The red colour is increased on exposing the stomach to the air. When the poison has been swallowed, the stomach may be found covered with white patches of arsenic, embedded in dark-coloured thick mucus, mixed with blood. Dr. Paterson thus describes the condition of a stomach he examined: Its lining membrane was generally very red and injected; but in addition there were very numerous stellated patches of vivid red, leading to a darker tint; in the centre of some of them was noticed a minute clot of blood; in others, an exceedingly rough particle of a crystalline substance, which was afterwards found to be arsenious acid. Perforation of the stomach is extremely rare, if it has ever occurred, but ulceration of the same organ has been observed in a person who died from the effects of arsenic in *five* hours (Christison, on *Poisons*, p. 340). In opposition to all the statements just made it has been shown that arsenic may prove fatal without leaving any inflammatory sign of its action (R. *v.* M'Cracken; R. *v.* Newton).

The mouth, pharynx, and gullet are generally found free from any inflammatory action. The small intestines may or may not be affected: in most cases the duodenum alone shows any signs of irritation. The rectum is that part of the large intestine most prone to inflammation. The other internal organs—the liver, spleen, and kidneys—do not appear to be appreciably affected by arsenic.

Due probably to the antiseptic properties of arsenic, the stomach and intestines retain for a long period after death the appearances of irritant poisoning. In two cases, this was so

well marked as to be visible—in the one case, *twelve* months, and in the other, *nineteen* months after interment. In suspected cases portions of the liver should aways be preserved and examined for arsenic (see p. 251).

The Period after Death when Arsenic may be Detected.

Arsenic is an indestructible poison, and may be found in the body after many years. In one case it was detected after the lapse of fourteen years. Arsenic has the power, to a certain extent, of arresting putrefactive changes; the stomach may, therefore, be found well preserved, and with the signs of inflammatory action present after the lapse of many months, and after putrefaction has far advanced in other parts of the body. When a person is suspected of having been poisoned with arsenic, and nothing but the skeleton is left for investigation, the arsenic should be looked for specially in the bones of the pelvis and the neighbouring spinal vertebræ (Watt's *Dictionary of Chemistry*, Sup.).

In reference to the preservative action of arsenic upon the tissues of those poisoned by it, the appearances of the bodies of the victims of Flannagan and Higgins, recorded by Whitford (*B. M. J.* 1884, vol. i. p. 504), are interesting. Arsenical poisoning having been established in one of three victims, the bodies of two others, Mary Higgins, aged ten years, and John Flannagan, aged twenty-four years, were exhumed and examined. The abdominal viscera of Mary Higgins yielded one grain of arsenious acid, and although the body had been interred for about thirteen and a half months, it was well preserved. A remarkable state of preservation obtained in the body of John Flannagan, who had been interred for thirty-seven and a half months; the face and body generally could be easily identified. Three and a half grains of arsenious acid were found in the abdominal viscera. In these cases a peculiar appearance was found in the stomach and intestines, consisting of a golden-yellow pigment or coating of the mucous membrane of the parts. It was thought by some observers to be composed of arsenic sulphide, but Campbell, Brown, and Davies of Liverpool, as a result of their analysis of it, found that it did not contain any appreciable amount of arsenic, but consisted mainly of bile pigment.

In trials for arsenical poisoning, where an exhumation has been made, the question may arise whether the arsenic found in the body has been carried into it from the earth surrounding the coffin.

In reply, the following points must be kept in mind :—

1. Arsenic may occur in certain calcareous and ochrey soils.
2. In these soils no arsenical compound *soluble in water* has been found.
3. The arsenic of these soils is dissolved out by hydrochloric acid, proving their previous insolubility.
4. The arsenic is, therefore, probably in the form of an arsenite or arseniate of iron, lime, etc.
5. Careful experiments have rendered it evident that even "under the most favourable circumstances the dead human body does not acquire an impregnation of arsenic from contact with arsenical earth" (TAYLOR).
6. It has been suggested that the arsenical compound in the soil may be rendered soluble by the ammonia formed during putrefaction.

This last suggestion is negatived by the following facts :—

1. The production of ammonia ceases before the body arrives at that stage of decomposition when it is at all likely to be exposed to the action of the soil of the cemetery.
2. The production of hydrosulphuret of ammonia during decomposition would tend to the production of sulphuret of arsenic forming yellow patches in the substance of the organs, thus rather fixing the arsenic on particular parts than allowing it to percolate through the tissues of the body from external application.

Analysis of the Suspected Earth.—About two pounds of the earth should be boiled for some time in water; the supernatant liquid should then be poured off from the insoluble residue, and filtered. The filtered liquid, after concentration, may then be examined by the tests about to be described. If no arsenic be found, the earth may now be boiled with dilute hydrochloric acid, filtered, concentrated, and then tested as before. The first process shows that no compound of arsenic soluble in water is present; the second shows that the arsenic is in a state of combination, and therefore not likely to impregnate the body.

The Detection of Arsenic.

General Directions.—In cases of suspected poisoning by arsenic or antimony, the contents of the stomach should be mixed with distilled water acidulated with hydrochloric acid and filtered, and the filtrate placed in a stoppered bottle

lettered or numbered 'A' or '1.' The liver should be cut into pieces, some of which should be bruised in a mortar with distilled water acidulated as above mentioned, pressed and filtered, and the filtrate placed in a bottle marked 'B' or '2.'

The kidneys and portions of the other solid organs may also be treated as above. Each solution so obtained may be then tested by the processes about to be described. By these means the amount of poison in each organ may be estimated.

Before subjecting the organic mixture to Marsh's or Reinsch's processes, Brande and Taylor strongly recommend a modified course of procedure.

The contents of the stomach, vomited matters, etc., and the solid organs, finely divided, must each be separated and *thoroughly* dried in a water bath, then mixed with an excess of *strong* hydrochloric acid in a flask, and slowly distilled by means of a sand bath, the distillate carried into a receiver containing a little pure distilled water, and the process continued nearly to dryness.

If arsenic be present, the distillate contains the arsenic as chloride, and can be at once subjected with great facility to the usual tests for the presence of that metal. This mode of proceeding both facilitates and expedites the ordinary methods of testing, as it separates the arsenic present from the complex organic mixtures with which it is associated, and presents it in a comparatively pure form for identification. The process also admits of the residue left in the retort being examined for lead and the other metallic poisons.

Before the following processes are applied, some of the sediment from the contents of the stomach, or the vomited matters, may be collected and well washed. If this is boiled in distilled water and filtered, the following tests, known as "the liquid tests for arsenic," may be applied to the filtrate :—

1. *Ammonia-Nitrate of Silver*, prepared by adding a weak solution of ammonia to a strong solution of nitrate of silver, gives with arsenic a yellow precipitate of *arsenite of silver* soluble in nitric, citric, acetic, and tartaric acids, and ammonia.

2. *Ammonia-Sulphate of Copper*, prepared by adding ammonia to a dilute solution of sulphate of copper, gives with arsenic a green precipitate of *arsenite of copper*. This precipitate is soluble in the mineral and vegetable acids and ammonia, but is not affected by soda or potash. The precipitate, dried and heated in a reduction tube, yields octahedral crystals of arsenious acid.

3. *Sulphuretted Hydrogen.*—The suspected liquid should be first

slightly acidulated with *pure* hydrochloric acid *before* the sulphuretted hydrogen gas is passed into it, when, if arsenic be present, a yellow precipitate is formed, known to be such by the following tests :—

(1) Insoluble in water, ether, alcohol, the vegetable acids, and dilute hydrochloric acid, but decomposed by strong nitric and nitro-hydrochloric acids.
(2) Dissolved, if no organic matter present, forming a colourless solution, when potash, soda, or ammonia is added.
(3) The yellow precipitate dried and heated with soda and cyanide of potassium yields a sublimate of metallic arsenic.

N.B.—None of the above tests should be applied in the presence of organic matter. The soluble salts of cadmium and per-salts of tin give yellow-coloured precipitates with sulphuretted hydrogen.

(4) If stannous chloride dissolved in strong hydrochloric acid be added to a solution of arsenic in hydrochloric acid, metallic arsenic is thrown down as a precipitate. This is a fairly delicate test.

The following Table gives the differences between the Yellow Precipitates formed with Sulphuretted Hydrogen and Arsenic, Cadmium, and Per-Salts of Tin :—

	Arsenic.	Cadmium.	Per-Salts of Tin.
Colour.	Yellow.	Yellow.	Dirty yellow.
Action of ammonia.	Soluble.	Insoluble.	Insoluble.
Action of hydrochloric acid.	Insoluble.	Soluble.	...
With cyanide flux.	Sublimes as metallic arsenic.	Sublimes as brown oxide.	No sublimate.

Marsh's Process.—This method for the detection of arsenic is founded on the fact that the several compounds of arsenic, except the sulphide and metallic arsenic itself, form a gaseous compound with nascent hydrogen, from which it may be readily separated by appropriate treatment. The solution to be tested should, therefore, be prepared as proposed by Brande and Taylor, given on a preceding page.

Precautions.—(1) Absolute purity of reagents. (2) The sulphuric acid should be diluted with five times its weight of water, and allowed to cool. (3) The suspected fluid should be added gradually. (4) Generate the gas regularly. (5) If no stain be at once produced, keep a portion of the exit tube red-hot for at least one hour.

The usual form of the apparatus is that of a U-shaped glass tube, about one inch in diameter and eight inches high, supported in a vertical position on a wooden stand. One end of the tube is fitted with a tap, and terminates in a glass tube drawn to a fine point; the other end is closed with a cork.

The apparatus is used as follows: A piece of pure zinc is dropped into the tube, and shaken into such a position that it occupies the bottom of that limb of the tube which is furnished with the tap. Water is then added, and subsequently sufficient pure sulphuric acid to cause a moderately brisk evolution of hydrogen. The production of hydrogen gas from pure zinc and pure sulphuric acid is sometimes slow, and may be facilitated by adding a few drops of platinic chloride solution to the contents of the flask previous to the addition of the sulphuric acid. The gas being allowed to accumulate for a short time, the tap is then partially turned on, and the gas ignited; if, on depressing a piece of white porcelain momentarily in the flame, no deposit or discoloration occur, the reagents used may be taken as pure. The tap is now connected with a tube of thin, hard glass, drawn out to a fine point at the end and having a constriction in the middle. The liquid to be tested being now placed in the apparatus, the gas is again ignited, and a piece of white porcelain momentarily depressed in the flame, when, if arsenic be present, a black, circular, metallic-looking stain will appear, which has the following composition. In the centre is the unoxidised metal, round this is a mixed deposit, and outside this the zone of arsenious acid. While the gas is passing, the exit tube should be heated to redness a little behind the constricted part, when a dark ring will appear if arsenic be present. The black deposit on the porcelain may be either arsenic or antimony, but may be distinguished as follows:—

[Table

	Arsenic.	Antimony.
Nature of the stain .	Metallic brilliancy.	Absence of metallic lustre.
Effect of heat . .	Volatile.	Non-volatile.
Heated with a little nitric acid.	Dissolves.	Oxidises to a white insoluble powder.
Warmed with a strong solution of chloride of lime.	Dissolves immediately.	Slowly dissolved.
Treated with bisulphide of ammonium.	Detached but not dissolved, but if heated to drive off ammonia *yellow* sulphide formed.	Soluble: on evaporation, *orange-yellow* sulphide formed.
The nitric acid solution evaporated to dryness gives with nitrate of silver.	A brick-red precipitate soluble in ammonia.	No reaction, but if ammonia and potash are added, a black precipitate is ultimately formed.

The portion of the tube on which the dark ring has been deposited is now cut off, broken into fragments, and heated in a small, hard glass tube—when, if arsenic be present, a white sublimate will be obtained of well-defined octahedral crystals. If the sublimate be treated with sulphide of ammonium, it is detached but not perfectly dissolved, and on evaporation of the solution to dryness, a residue of the yellow sulphide of arsenic will remain, which, if heated with strong nitric acid, and evaporated again to dryness, will give a brick-red precipitate with nitrate of silver solution, soluble in ammonia. The process of Marsh may be used quantitatively by passing the issuing gas through a glass tube, dipping into a strong solution of argentic nitrate. A portion of the tube is kept at a red heat, when, if arsenic be present, it is deposited in the metallic form in the cool portion. The glass tube containing the stain is cut with a file and weighed. The stain is then removed by strong nitric acid, the tube dried and weighed: the difference in weight equals the amount of metallic arsenic. The nitrate of silver solution is now treated with pure hydrochloric acid, filtered, and the filtrate neutralised with sodium carbonate, titrated with standard solution of iodine. By dipping the end of the issuing tube into a fresh solution of argentic nitrate,

the absence of colour will show that all the arsenic has been obtained.

Instead of the U-shaped tube a Wolff's bottle or Erlenmeyer's flask may be used, and the exit tube carrying off the gas bent twice upon itself and connected with a glass bulb containing calcium chloride. From this bulb the long, hard glass tube proceeds, pointed at the end to form a gas jet; the gas is lighted at the end, and if a Bunsen flame be applied at a short distance from the end, a deposit of the arsenic, if present, will form on the distal side of the point at which the flame is applied.

Reinsch's Process.—First obtain a clear solution by filtration or otherwise, and then proceed as follows: Strongly acidify the liquid with hydrochloric acid, introduce some pieces of copper foil, and heat to near the boiling-point of the liquid. Both the acid and metal must be previously tested to ensure their freedom from arsenic. Any arsenic present will then be deposited on the copper in the metallic state, either in the form of a black lustrous deposit when the arsenic is present in any quantity, or else as a steel-grey coating when a minute quantity only is present. In either case, the copper foil, after remaining for some time in the suspected fluid, is taken out, cut into small pieces, introduced into the bottom of a hard glass tube, and heated to low redness, when the arsenic will sublime as arsenious acid in octahedral crystals, forming a ring in the cooler portion of the tube. The deposit is identified as arsenious acid by the form of the crystals, and by its deportment with the various reagents, as in the treatment of similar sublimates mentioned under *Marsh's Process.* Two precautions have to be taken in applying this test: do not use too large a portion of copper foil at first, and do not remove the copper too quickly from the boiling fluid. A solution containing arsenic acid or an alkaline arsenite, mixed with sulphuric acid, does not produce any deposit on metallic copper even after long boiling, unless the quantity of the arsenic present be considerable; the deposition may, however, be ensured by adding sulphurous acid or a sulphite, whereby the arsenic is reduced to arsenious acid (G. Werther, *J. Pr. Chem.* lxxxii. 286; *Jahresb.* 1861, p. 851).

Objections to Reinsch's Process.—The chief objection to Reinsch's process is the possible impurity of the reagents used

—both these reagents, even when supplied as pure, being liable to contain traces of arsenic. As met with in commerce, both hydrochloric acid and metallic copper invariably contain minute quantities of arsenic, the former generally containing the larger quantity of that impurity. Although, by purchasing the purest possible reagents, specially prepared for analysis, it may be possible to ensure their freedom from arsenic, yet in all cases they should be tested before using them. Some of

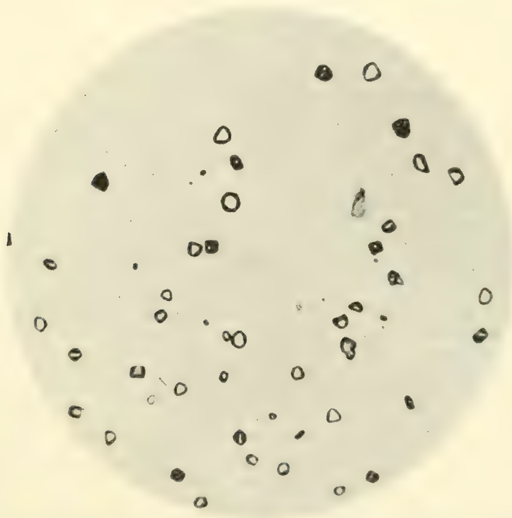


FIG. 25.—Photo-micrograph of sublimate of arsenious acid obtained by Reinsch's process, ×250. (R. J. M. Buchanan.)

the hydrochloric acid should be diluted with distilled water, and gently heated with the copper foil. If no tarnishing or deposit of any kind occurs on the metal after a lapse of several hours, the reagents may be taken as pure and the trial of the suspected substance at once made.

Professor Abel has proposed the following process to ensure the purity of the copper and acid: Boil together equal portions of strong hydrochloric acid and a solution of perchloride of iron. While the mixture is boiling immerse the copper foil,

which, if pure, will be merely brightened in colour; if impure, a black deposit on the metal is formed.

Bloxam's Method for the Detection of Arsenic.—The late Professor Bloxam suggested an admirable and delicate process for the detection of small quantities of arsenic. The method is, like that of Marsh, founded on the property possessed by nascent hydrogen of forming a gaseous compound with arsenic; but, instead of the hydrogen being generated by the action of dilute sulphuric acid on zinc, Bloxam generates the gas by an electric current.

The wires from the extremities of a battery terminate in small plates of platinum foil, which are plunged into the liquid to be tested, the apparatus being so arranged that the hydrogen gas evolved from the negative pole is collected. The issuing gas is tested in a similar manner to that obtained in Marsh's process.

This method of Bloxam's is exceedingly delicate, and possesses one great advantage, that no zinc being used, there is no danger of contamination by the use of impure metal; while, as nothing foreign is introduced during the process of testing, the liquid under examination is left pure for the application of other tests if necessary.

Gutzeit's Test.—This test is more sensitive to the presence of minute quantities of arsenic than that of either Reinsch or Marsh. The apparatus devised by Dowzard should be used (*Journ. Chem. Soc.*, vols. lxxix. and lxxx. 463, p. 715), which consists of an Erlenmeyer's flask fitted with superimposed cells, containing solutions which will wash or neutralise those gases which would interfere with the accuracy of the result. The following is Dowzard's description of the method of using the apparatus:—

"A weighed or measured portion of the sample is mixed with 5 c.c. of pure HCl (if the sample is alkaline it must be neutralised first), four drops of a 15 per cent solution of cuprous chloride in hydrochloric acid are then added, and the mixture made up to 30 c.c. with water; if it is not convenient to work with such a small bulk as 30 c.c. this quantity may be doubled or trebled, but the same proportion of acid should be used. A rod of pure zinc, 3 cm. long and 5 mm. in diameter, is first placed in the flask, the above mixture is then introduced and the first cell placed in position; lead acetate solution 5 per

cent is now poured into the cell until it is about half full. The second and third cells are filled in a similar manner; a small tuft of cotton wool is introduced into the neck of the top cell, and its mouth capped with mercuric chloride paper, which may be held in position by an elastic band or a glass collar made from a piece of glass tubing. After forty minutes or more the cap is removed and examined in full daylight. A minute trace of arsenic is indicated by a lemon-yellow spot, which varies in tint according to the amount present; and a heavy trace by an orange-brown spot. The mercuric chloride paper is prepared as follows: one drop of a 5 per cent solution of mercuric chloride is allowed to fall on the centre of a piece (4 cm. square) of thin Swedish filtering paper, such as Muncktell's No. 1 F.; the paper is dried before using." The lead acetate in the cells absorbs any H_2S gas given off, and if additional cells contain a 15 per cent solution of cuprous chloride in hydrochloric acid, PH_3 is also prevented from passing and causing a stain. By this method arsenic can be detected in the presence of 2500 times its weight of antimony. The presence of selenium and tellurium compounds does not interfere with the usefulness of this method.

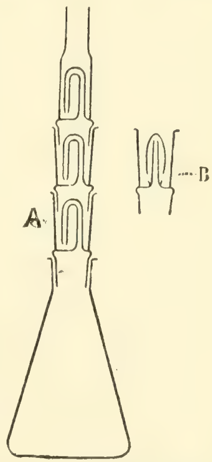


FIG. 26.—Dowzard's apparatus for Gutzeit's test for arsenic. A and B indicate glass cells or traps which contain solutions of lead acetate and copper chloride for the purpose of fixing H_2S and PH_3 which otherwise would react upon the mercuric chloride spot on the filter-cap. The cells are fitted into one another, as shown in the figure.

Fatal Dose.—Two grains in solution have been known to cause death. Recoveries have, however, occurred after an ounce or more of the poison has been taken. Much will depend upon the fulness or emptiness of the stomach at the time the poison is taken, and also upon the vehicle in which the poison is administered. Vomiting and purging are more urgent when the dose is large, probably assisting to get rid of the arsenic before its fatal action is produced.

Fatal Period.—From twenty minutes to two or three weeks, and even later from the secondary effects of the poison. Any

thick medium, cocoa or soup, will of course delay the action of the poison.

Treatment.—Vomiting should be promoted, and diluent drinks largely given. The stomach pump, if it can be procured without much delay, should also be employed to empty the stomach. Emetics of sulphate of zinc should be given without delay—followed by the administration of milk, lime-water, and albumen. Symptoms as they occur must be treated on general principles.

The hydrated sesquioxide of iron, and the hydrated oxide of magnesia, and animal charcoal have been proposed and used as antidotes. The sesquioxide of iron can be prepared ready to hand by saturating the tincture *ferri perchloridi* with ammonia or washing soda. It should be given freely. Drachm doses of dialysed iron in water may be administered. Reputed antidotes are useless when the poison is in the solid state. The diarrhœa, tenesmus, collapse, pain, and nervous symptoms should be treated on general principles.

Other Poisonous Compounds of Arsenic.

Arsenical Vapour.—The vapour from the flues of the copper and arsenic smelting-works in Cornwall, escaping into the air, may cause death to cattle, and the destruction of vegetation. The workmen in these works not infrequently suffer from eruptions on the skin, and from great constitutional derangement; but, on the whole, taking into consideration the dangerous nature of their employment, the men appear to enjoy average health. Actions for damage and nuisance have resulted from the escape of this vapour from the factories.

Arsenite of Potash.—A solution of arsenite of potash, mixed with the tincture of red lavender (the solution contains four grains of arsenious acid in one ounce)—better known as FOWLER'S SOLUTION, or as FOWLER'S MINERAL SOLUTION or TASTELESS AGUE DROP. It is probably a solution of arsenious acid in carbonate of potash, and not a true arsenite of potash. This preparation is much used as a domestic remedy in ague in the Fens of Cambridgeshire. Death from its use is rare; but it is, nevertheless, too dangerous a medicine to be used recklessly. Idiosyncrasy has much to do with the action of the drug, some persons taking even large doses with impunity,

whilst, in others, the smallest medicinal dose has produced alarming symptoms. It is stated that the Styrian arsenic-eating peasant is capable of taking without injury five grains of arsenious acid for a dose ; and in one case of suspected murder in Styria, the prisoner was acquitted as the deceased was known to be an arsenic-eater.

Donovan's Solution.—A solution of hydriodate of arsenic and mercury. Now officinal, and much used by many practitioners.

Sheep Dip.—The mixture used for washing sheep, composed of tar-water, soft soap, and arsenic, has caused death in twenty-four hours. The men engaged in dipping the sheep may suffer both locally and constitutionally from the effects of the arsenic in the solution.

Treatment.—As before described.

Analysis.—See pp. 303 *et seq.*

Arsenite of Copper.—Scheele's green, and the aceto-arsenite of copper, Schweinfurt-green, are met with in commerce and the arts as green pigments. Among workmen they are familiarly known as emerald-green, Brunswick-green, or Vienna-green. In France, the term *vert Anglais* or English-green, has been given to them. Scheele's green contains about 55 per cent of pure arsenious acid ; the other, Schweinfurt-green, about 58 per cent.

These colours are employed for various purposes, among which the following may be mentioned :—

1. Artificial flowers and other articles of dress.
2. Confectionery, pastry ornaments, and toys.
3. As green paint for the insides of houses.
4. In the green-colour for wall-papers.
5. In the green-coloured paper lining boxes, etc.
6. Green-coloured tapers used for artificial lighting.

The employment of emerald-green in the colouring of wall-papers is so extensive, that in the year 1860 an English paper-stainer stated that he used two tons of arsenic weekly. In 1862 the amount of this colour manufactured during the year was from 500 to 700 tons. Numerous cases of chronic arsenical poisoning have resulted from the presence of arsenic in the form of Scheele's green and Schweinfurt-green in wall-papers and other articles. As the colour is only loosely applied to the surface by

means of a weak solution of size, it is easily brushed off, and may so impregnate the air of a room as to produce injurious effects on those who inhabit the apartment. By fermentation of the starch paste used for fastening the paper to the walls, nascent hydrogen is liberated, and, combining with the arsenic to form arseniuretted hydrogen, passes into the air of the room and is inhaled. This gas is extremely poisonous, and small quantities suffice to produce serious results. Certain moulds are endowed with the power of living in materials containing arsenic, and of decomposing arsenious acid or its salts into the gaseous form known as *diethylarsine*; there are altogether ten such moulds, and the most active is the *Penicillium brevicaule*.

In the case of ladies' dresses, the following method is adopted :—

The colouring material is made by thoroughly stirring together a mixture containing, in definite proportions, the green pigment, cold water, starch, and gum arabic, or some similar substance which shall give the colour consistence and adhesiveness. Not infrequently in this process the hand and forearm are freely used in the liquid to expedite the work. Of this mixture, properly prepared, the workman takes a quantity in his fingers and roughly spreads it over the muslin or fine calico. The fabric is then beaten and kneaded between the hands until it is uniformly coloured. The longer this process is continued, the more perfect is the result. The cloth is now fastened to a frame for drying. In all this process of colouring, the hands, forearms, and frequently also the face of the operative must become soiled with the green colour. It will be also observed that the colour is but loosely applied, *no mordant being used*, as in calico printing, to fix the pigment in the texture of the cloth.

Symptoms.—All the effects produced by arsenic may result from the use of articles coloured with these pigments. Chronic inflammation of the stomach and bowels, and irritation of the eyes, accompanied in some cases with extreme nervous debility and prostration, are by no means uncommon in those employed in the manufacture of this "cheerful," but poisonous colour. The skin of the hands, arms, and scalp is often attacked by a vesicular eruption or an erythematous redness. When it is borne in mind that, according to the analysis of Hoffman, a single twig of twelve artificial leaves may contain as much as ten grains of pure arsenic, it is not to be wondered at that the most serious results have occurred from the reckless use of these colours. In Prussia and France the use of the arsenical colours is prohibited.

Analysis.—Scheele's green is insoluble in water, but is soluble

in ammonia, the solution having a blue colour, from the separation of the arsenious acid from the oxide of copper. If a few drops of the blue ammoniacal solution be poured on some crystals of nitrate of silver, the yellow arsenite of silver is formed. The blue ammoniacal solution, if acidified with HCl and boiled with pure copper foil, deposits arsenic on the copper, which, if cut into strips and placed in a small reduction tube and heated, sublimes and is deposited in octahedral crystals on the cold portion of the tube. The tests before described are applicable for the detection of this substance.

Orpiment.

Orpiment, or yellow arsenic, one of the sulphurets of arsenic, has been used occasionally as a poison. It is also largely employed in the arts for paper-staining and for colouring toys. In cases of arsenical poisoning, it is this compound that is commonly found adhering to the stomach and intestines. It is formed by the sulphuretted hydrogen, the result of decomposition, acting on the white arsenic swallowed.

Realgar.

Realgar, or red arsenic, is another of the sulphurets of arsenic, and, like orpiment, is largely used in the arts as a colour. It is also employed, like orpiment, as a depilatory, fatal results having followed its use for this purpose. The colour of this substance prohibits its frequent use as a poison.

Both of these compounds owe their poisonous properties to the amount of free arsenious acid which they contain, and which may be as much as 30 per cent.

Symptoms.—The symptoms produced by these substances are similar to those caused by arsenic. The fatal dose will depend on the amount of free arsenious acid which they may each contain.

Treatment.—Emetics and demulcent drinks.

Analysis.—As before.

Metallic Arsenic, etc.

Metallic arsenic, fly powder, arsenic acid, largely used in the manufacture of magenta, aniline red or fuchsine, and the

arseniates of potash and soda, are all poisonous. The *papier moure* of the shops consists of blotting-paper steeped in a solution of arseniate of potash. Macquer's neutral arsenical salt is the binarsenate of potash.

Symptoms.—The symptoms are those of arsenical poisoning.

Treatment.—When metallic arsenic has been taken, vomiting must be promoted by the use of proper emetics. Tartar emetic should never be used. In the treatment for poisoning with arsenic acid, or of the arseniates of potash and soda, the hydrated oxide of iron, or of the acetate of iron, should be used, as the arseniates are precipitated by the iron.

Arsenic Acid.

No case of poisoning by this substance has been recorded, for, although poisonous, it is better known in the laboratory than in the shops. It differs from arsenious acid in being only partially volatilised by heat, in its solubility in water, and in being precipitated of a brick-red colour by nitrate of silver. With sulphuretted hydrogen a yellow precipitate is slowly formed, insoluble in hydrochloric acid.

Arsenuretted Hydrogen.

This gas has proved fatal in several cases. It is generated in the process known as Marsh's process for arsenic, and is so poisonous that a very small quantity, not sufficient to be detected by its odour, has caused death. In most cases death has been the result of accident.

Symptoms.—Giddiness, fainting, constant vomiting, pain in stomach, and suppression of urine, with rapid destruction of the red blood corpuscles, are among the most prominent symptoms.

The *post-mortem* appearances are inflammation of the stomach, with more or less softening of its coats. The liver and kidneys are also more or less affected, and have been found of a deep indigo colour.

Analysis.—This has been described when speaking of Marsh's process for arsenic.

Cacodylic Acid.

Cacodylic acid and the cacodylates are poisonous. The acid dissolves easily in water and alcohol, and it unites with many metals and organic substances to form salts. Although it is held by some to be non-poisonous, Murrell asserts that the administration of cacodylate of sodium produces symptoms "far more severe than those which follow the exhibition of arsenic in its ordinary forms" (*B. M. J.* 1900, vol. ii. p. 1823; 1901, vol. i. p. 120).

Professor Fraser of Edinburgh, on the other hand, from clinical observation and chemical tests, affirms that cacodylic acid and the cacodylates are extremely stable bodies, and the arsenic in them is with such great difficulty set free that it passes through the body in combination as an inert substance (*B. M. J.* 1902, vol. i. p. 713).

Arsenical Contamination of Food Stuffs.

Arsenic is found associated with many other substances in nature, particularly copper and pyrites. Arsenic is commonly present in commercial sulphuric acid manufactured from pyrites containing the metal, and when such acid is used with common salt for the production of hydrochloric acid, the latter also becomes contaminated. It may be safely stated that commercial sulphuric acid, hydrochloric acid, copper and zinc, free from arsenic, do not exist in the market. Hence in the detection of arsenic by the toxicologist, the absolute purity of these reagents, which he uses, must be established.

In the manufacture of glucose, arseniferous sulphuric acid has been the means of contaminating it. Ritter and Blyth pointed out the danger, by this means, of conveying arsenic into beer, confectionery, syrup, and other food stuffs. Glucose made with such acid, and used in the manufacture of beer, was the cause, in the year 1900, of a widespread and serious epidemic of arsenical poisoning in Manchester and Liverpool, in which several thousand persons suffered. Arsenic may also contaminate grain during malting by the use of anthracite coal or sulphur bar in the kilns.

Recapitulation of the Leading Facts with regard to Poisoning with Arsenic.

Acute Poisoning.—Symptoms, etc.

Action on alimentary canal	Intense irritation of the stomach, upper part of small intestine, and lower part of the large. The inflamed condition of the stomach occurs even if arsenic be absorbed by the skin. Not present in *all* cases.
Circulation . . .	The heart weakened, with a consequent reduction in force and frequency of pulse.
The brain and nervous system.	In some cases the action upon the brain is that of a narcotic, and the paralysis sometimes seen appears to be due to a direct action of the drug on the cord.
The urinary organs . .	Arrest of the action of the kidneys is not uncommon. Stranguary.
Fatal dose . . .	Two grains.
Average period of the commencement of the symptoms.	From half an hour to an hour after the poison is taken.
Average period before death.	Ten to twenty-four hours.

Chronic Poisoning.—Symptoms, etc.

The eyes, nose, and mouth	Irritation and redness of the eyes and nostrils. Dryness of the mouth and throat.
The stomach and bowels .	Loss of appetite, colicky pains, cramps, irritability of bowels, mucous discharges.
Nervous system . .	Depression and irritability of spirits, sleeplessness, giddiness, convulsions, vertigo, paralysis, etc.
Cutaneous surface . .	Brown pigment deposit in the skin of the face. "Eczema arsenicale," etc.
Means of diagnosis in suspected cases.	Examine the urine unostentatiously. Remove patient from present abode. Examine wall-paper, etc., for arsenic.
The probable *post-mortem* if death is due to this poison.	Signs of irritation, slight or absent, in stomach and bowels.
Organs most important to secure for analysis.	Liver, stomach, kidney.
Circumstances under which it may occur independently of criminal administration.	Green wall-papers, coloured toys and sweets, green tarlatan dresses, etc.

ANTIMONY.

Antimony, the Stibium of the ancients, is obtained from the native sulphide. Metallic antimony is of a bluish-white colour, crystalline and brittle. It melts at about 840° F., and is slowly volatilised at a white heat.

Two compounds of antimony—tartar emetic and chloride of antimony—are alone of any toxicological interest.

FIG. 27.—Photo-micrograph of crystals of tartarated antimony, ×50. (R. J. M. Buchanan.)

Tartar Emetic.

Antimonium Tartaratum. Tartarated Antimony.

Tartar emetic occurs as a white powder; sometimes, however, with a yellowish tint. It is soluble in about three parts of boiling water and fifteen of cold, and insoluble in alcohol.

The *vinum antimoniale* of the Pharmacopœia contains two grains of the salt in an ounce of wine.

Before 1856 poisoning by antimony was of rare occurrence,

but since that year several cases of chronic poisoning have occurred, giving to this substance considerable importance.

Symptoms of Antimonial Poisoning.

Acute.—Tartar emetic is an irritant poison, but possesses slight corrosive properties. When taken in large doses, two or three drachms, it gives rise to a metallic taste in the mouth, which is not easily removed. In most cases, violent vomiting

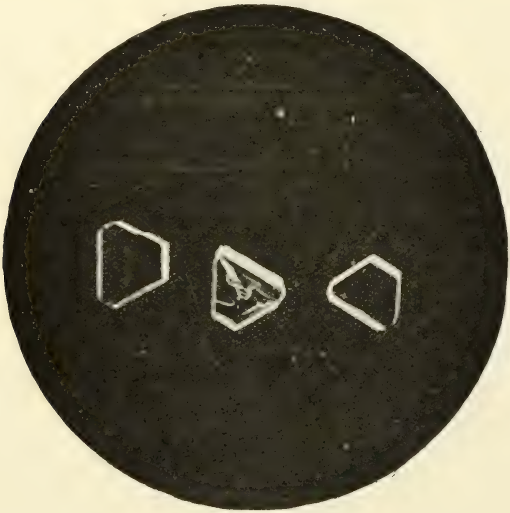


FIG. 28.—Photo-micrograph of crystals of tartarated antimony, ×50. (R. J. M. Buchanan.)

follows immediately after the poison is swallowed, the vomiting continuing even after the stomach is emptied of its contents. In a few cases, however, even when a large dose has been taken, vomiting may be absent. Burning pain is felt at the pit of the stomach, accompanied with cramps in the belly and purging. There is considerable difficulty in swallowing, and the patient complains of tightness and constriction in the throat. The mouth and throat in some cases are excoriated, or covered with whitish aphthous-looking spots, which ultimately become brown or black. In some cases, the thirst is

intense; in others, absent or nearly so. Cramps in the lower extremities, almost amounting in some cases to tetanic spasms, followed by extreme depression, are generally the precursor of a fatal termination. The urine may be suppressed, as is the case in arsenical poisoning; in some cases it has even been increased. On this point, however, the statements of observers differ. Trousseau says that the urine is suppressed; Huseman that it is *never* suppressed. The skin is in some cases covered by a pustular eruption, not unlike that of smallpox. Dobie has recorded a case of poisoning by tartar emetic in which a comatose condition was present. In antimonial poisoning, even in the most desperate cases, there is always greater hope of recovery than in arsenical poisoning.

Chronic.—The symptoms which mark the chronic form of poisoning differ chiefly in being less intense and less rapid than in the acute. Chronic poisoning by small repeated doses is that form of poisoning which appears most in vogue of late years—as certain diseases, enteritis, etc., can be simulated by the administration of repeated small doses. The unfortunate victim complains of constant nausea and retching, with great depression. Food is objected to, as it only increases the vomiting. The matters vomited are at first merely mucus, but after a time they become mixed with bile. Each time the poison is repeated, the symptoms become aggravated. Emaciation gradually sets in, and the person dies from complete exhaustion, or from the effects of a larger dose than usual. Chronic poisoning has given rise to several errors in diagnosis, and the histories of recorded cases should put medical men on their guard. In all doubtful cases examine the urine.

Post-mortem Appearances.—The mucous membrane of the throat, gullet, and stomach is inflamed, and in some places softened and corroded. Aphthous-looking spots are not infrequently found on the mucous membrane of the stomach, and these may also be observed on the throat and on the small intestines. The liver has been found in some cases of chronic poisoning, where the fatal termination has been for some time retarded, enlarged, and its structure so soft as to be easily broken down. Fatty degeneration of the internal organs has been found after protracted fatal administration of the drug. It is stated that in Brunswick the fatty livers of the geese are produced by the judicious administration of antimony. The

appearances above detailed may be more or less absent or present, according to the time that may have elapsed from the swallowing of the poison to the time at which death has occurred.

At the *post-mortem* examination on the body of Mr. Bravo, poisoned with tartar emetic in 1876, the mucous surfaces of the stomach and duodenum were found pale and yellowish. Ulcers were present in the cæcum, and the rest of the large intestine blood-stained, but not ulcerated. Stevenson records the *post-mortem* appearances of the bodies of three women poisoned by tartar emetic (*B. M. J.* 1903, vol. i. p. 873). They are of peculiar interest in reference to the preservative action of antimony upon the bodies of those poisoned by it. In the case of M. E. Marsh, upon whose body the examination was made eight days after death, there was no odour of putrefaction, the bowels were in a condition of acute catarrh and streaky congestion without ulceration.

The body of Bessie Taylor had been buried for twenty-one months; ordinary putrefactive changes were absent, and with the exception of the integuments, it was in a remarkably good state of preservation. The alimentary canal showed acute non-ulcerative gastro-enteritis, the stomach and duodenum were of a cinnabar-red colour, the jejunum also in patches. The ileum was covered with orange-red mucus in its lower portion, and there was an orange-coloured patch twelve inches above the ileo-cæcal valve. The patch on analysis was proved to contain antimonious sulphide. Similar orange patches were present in the colon and upper portion of the rectum. There were no ulcerations, but the mucous membrane of the intestines was of a dull cinnabar-red colour.

The body of Mary J. Spink was exhumed five years after burial, and presented a life-like aspect; there was no putrefactive odour, and no larvæ present. The stomach and intestines were of a cinnabar-red colour; there were no ulcerations; the intestines contained orange-coloured mucus.

Elimination of Antimony from the System.

Antimony, taken in a large dose, or in small doses frequently repeated, appears to be rapidly absorbed, and then eliminated from the system by the kidneys. Dating from the time at

which the poison was swallowed, it will be found in the organs of the body in the following order:—

1. Stomach and bowels, but slightly in the liver.
2. Absent from the stomach, but present in the liver, spleen, and kidneys—traces in the blood.
3. Present in the fat and bones, with traces in the liver, fæces, and urine.
4. The period required for its complete elimination from the vital organs varies from fifteen to thirty days.

In other words, the presence of antimony in the stomach and intestines points to the recent administration of the poison; and its absence from those organs, and presence in the others above mentioned, to a more remote period of administration. It has been suggested that in some cases the poison may be eliminated by the mucous membrane of the stomach. This assumption has been proved to be correct, for it has been shown that antimony may be found in the stomach after the inhalation of antimonietted hydrogen.

Fatal Dose.—It is impossible to state with certainty the exact amount of antimony—tartar emetic—which may prove fatal, as recoveries have taken place even after an ounce had been taken. Large doses are uncertain in their effects, as the severe vomiting which they produce generally helps to get rid of the poison. In small doses, death may result from the depressing action which it exerts over the heart.

Fatal Period.—From a few hours to several weeks, and even months.

Treatment.—Promote vomiting by the administration of warm water, or warm greasy water, or the stomach may be washed out with syphon tube, unless the chloride of antimony is the poison, and then give tannic acid in drachm doses in warm water, or any vegetable infusion containing tannin—viz. tea, oak bark, or cinchona bark. Demulcent drinks may be administered, and warmth applied. Opium may be given to relieve pain, and stimulants for the depression.

The Detection of Antimony.

Prepare the solutions of the liver and other solid organs, and also the contents of the stomach, as described under the detection of arsenic, using tartaric acid instead of hydrochloric acid. Through a portion of one of the solutions, obtained by

filtration or dialysis, pass a current of sulphuretted hydrogen, which will produce, if antimony be present, an orange-coloured precipitate of the sulphide of antimony. The precipitated sulphide is dissolved by hot hydrochloric acid with the evolution of sulphuretted hydrogen; and if the resulting solution be poured into water, a white precipitate is formed of oxychloride of antimony, soluble in tartaric acid. Chloride of bismuth is precipitated when poured into water, but the precipitate is turned black by sulphide of ammonium, the antimonial orange-red; the precipitate of bismuth is not soluble in tartaric acid, the antimonial is soluble.

Marsh's and Reinsch's processes may also be used for the detection of antimony. The former is, however, open to the objection that antimony, when present in any quantity, rapidly precipitates on the zinc in the form of a flocculent black deposit, while the issuing gas is found to contain only traces of the metal.

Reinsch's process is, however, very delicate, and its application is in every respect similar to that in use for the detection of arsenic. The acid liquid should, however, be boiled down to a small bulk with the copper, before a conclusion is drawn as to the entire absence of the metal.

TABLE GIVING THE CHARACTERISTIC REACTIONS OF ANTIMONIAL AND ARSENICAL DEPOSITS ON COPPER.

	ANTIMONY.	ARSENIC.
The colour of the deposit on copper by Reinsch's process is—	Lustrous, with a violet hue.	Dark steel-grey colour, and lustrous.
The coated copper heated in the end of a small tube.	No effect, or only a trifling white sublimate, non-crystalline, non-volatile. If the sublimate be dissolved in solution of tartaric acid and sulphuretted hydrogen passed through the solution, the orange antimonious sulphide is thrown down.	Well-marked sublimate of octahedral crystals; is readily volatile.

It may be noted that mercury likewise yields a deposit on copper with Reinsch's process ; but the coating is in this case either of a grey colour or white, and silvery on the application of friction. When the coated copper is heated in a glass tube, there is a sublimate of metallic mercury readily aggregating into globules on being rubbed with a glass rod. If the deposit is trifling in quantity, a magnifying-glass should be used to identify the metallic globules. This test at once distinguishes a deposit on copper due to mercury from that produced under similar conditions by arsenic or antimony.

Quantitative Analysis.—Take a measured quantity of the suspected liquid and precipitate thoroughly with sulphuretted hydrogen. Wash, dry, and weigh precipitate. One hundred parts equal 202·78 parts of crystallised tartar emetic.

Recapitulation of the Leading Facts with regard to Poisoning with Antimony.

ACUTE POISONING.—SYMPTOMS, ETC.

Action on alimentary canal.	Intense irritation of the stomach and bowels, constant vomiting, and frequently purging. Eliminated by the stomach when absorbed by the skin, or as antimonietted hydrogen by the lungs. Presence, in some cases absence, of signs of inflammation in intestinal canal.
Circulation . . .	The cardiac contractions are lessened in frequency and force, the heart being finally arrested in diastole.
Brain and nervous system.	Sometimes delirium, paralysis of sensation and motion, and diminution of reflex action.
Urinary organs . .	Secretion of the kidneys, as a rule, not arrested ; sometimes increased.
Fatal dose . . .	Two grains.
Average period of commencement of symptoms.	A very short time after the poison is taken. Almost immediately.
Average period before death.	Various. Ten to twenty hours.

CHRONIC POISONING.—SYMPTOMS, ETC.

Mouth	Aphthous spots on mouth, metallic taste.
The stomach and bowels	Constant irritation, nausea, sinking at the stomach, symptoms of enteritis or cholera, purging, tenesmus, etc.
Nervous system . .	Malaise, low spirits, giddiness, delirium.
Cutaneous surface .	Pustular eruption like smallpox, sweating, decrease in temperature.
Means of diagnosis in suspected cases.	Same as for arsenic.
The probable *post-mortem* if death is due to poisons.	Much the same as in arsenic poisoning.
Organs most important to secure for analysis.	Liver, stomach, and kidneys.

MERCURY.

Metallic mercury possesses no toxicological interest, as it appears to be almost inert, even in very large doses. If applied to the skin in a finely-divided state, as in mercurial ointment, or internally, as blue pill, its toxic effects may be produced. The vapour given off from the metal is highly poisonous, producing salivation, emaciation, and death. A singular accident of poisoning by mercurial vapour occurred on board H.M.S. *Triumph* in 1810, owing to the bursting of bladders containing large quantities of the metal; in three weeks 200 men were affected with salivation, etc., nearly all the cattle on board died, as well as the mice, a dog, and a canary-bird.

Corrosive Sublimate.

This is the most important of the preparations of mercury. It occurs either in crystalline masses of prismatic crystals or as a white powder. It is now known among chemists as the perchloride, though it is frequently spoken of as the bichloride, chloride, and oxymuriate of mercury. It has a powerful metallic and styptic taste, and is soluble in about sixteen parts of cold water and three of boiling water. Alcohol and ether readily dissolve it, *the latter having the power of abstracting it*

from its solution in water. This property of ether is of importance as a means of separating corrosive sublimate from its solution in other liquids. It is important to remember that corrosive sublimate *is* soluble in alcohol (R. *v.* Walsh). The liquor hydrargyri perchloridi of the Pharmacopœia contains half a grain of the salt to a fluid ounce of water. Half a grain of the muriate of ammonia is added to increase the solubility

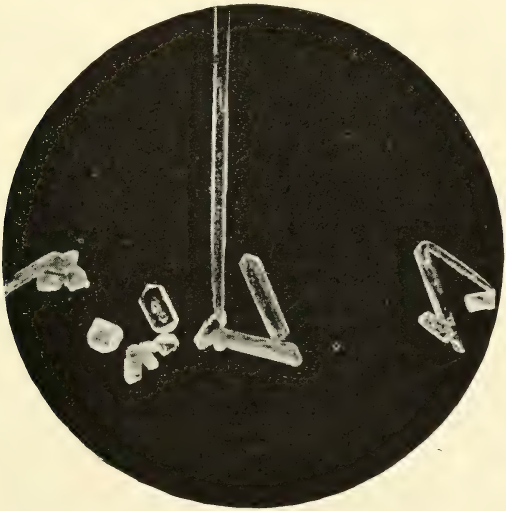


FIG. 29.—Photo-micrograph of crystals of corrosive sublimate, ×50. (R. J. M. Buchanan.)

of the mercurial salt. Applied externally to the unbroken skin, corrosive sublimate has caused death in several cases, the symptoms being almost identical with those which follow the entrance of the poison into the stomach. Toxic symptoms have followed intra-uterine or vaginal injections of solution of perchloride of mercury, also when it has been used to wash out abscess cavities. Acute poisoning, in some cases fatal, has resulted from the external application of corrosive sublimate to ulcers and tumours.

Symptoms of Poisoning by Corrosive Sublimate.

Acute.—The symptoms come on almost immediately the poison is swallowed. A strong metallic coppery taste in the mouth is experienced, and a choking sensation in the throat. Pain of a burning character is felt, extending from the mouth to the stomach, followed by nausea and vomiting of stringent mucus, more or less tinged with blood, and violent purging, the evacuations being also mixed with blood and mucus. The pulse is feeble, quick, and irregular; the countenance flushed or pale, and the tongue white and shrivelled. This appearance of the tongue is not present in all cases. The skin is cold and clammy, and the functions of the kidneys are arrested, there being in many cases complete suppression of urine. As is the case with other irritant poisons, the symptoms and effects produced admit of considerable variation. Thus, there may be no pain in the stomach, and no purging. Salivation is present in some cases, but chiefly in those in whom the fatal termination is somewhat prolonged. This sign is not infrequently absent. Poisoning with corrosive sublimate differs from arsenical poisoning in the following particulars:—Corrosive sublimate has a distinct metallic taste, arsenic is almost tasteless; the symptoms in the former supervene immediately the poison is swallowed, in the latter there is a short delay. The discharges in corrosive sublimate are more frequently bloody than in arsenic poisoning.

Chronic.—The symptoms present in this form of poisoning are modified by the size of the dose, and the interval allowed to elapse between each dose. Nausea, followed by occasional vomiting, and pains in the stomach, are complained of by the patient. There is general constitutional disturbance, with anæmia and cachexia, and consequent mental depression. Salivation, as might be expected, is a more prominent symptom than in acute poisoning; but the salivation may be intermittent—that is, it may cease and then reappear, even after the lapse of months, without an additional dose of mercury having been given in the interval. Salivation may also come on in the course of certain diseases, attacking the salivary glands, and it may also be produced by other causes—pregnancy, etc. The glands of the mouth become swollen and painful, the

gums tender, and the teeth loosened fall out of the mouth. Periostitis of the jaw may occur. The breath has a peculiar, offensive smell, the bowels are irritable, and diarrhœa is not infrequently present. It must be borne in mind that in certain diseases—granular disease of the kidney—the smallest dose of any mercurial preparation may produce profuse ptyalism. And the toxicologist must be careful not to mistake the affection known as *cancrum oris*, or "the canker," most common in delicate, ill-fed children and adults, for the effects of mercury. The nervous system is more or less affected, neuralgic pains and mercurial tremors being present in many cases. The tremors commence in the tongue and face and spread to the arms and legs—they are similar to those of paralysis agitans; at first they are invoked by exertion, finally they become continuous; they cease during sleep. Paralysis may also occur, especially in those exposed to the vapour of mercury. Habit appears to exert some influence on the action of corrosive sublimate, if we may accept the story of the old man of Constantinople, who for thirty years took large doses till his daily allowance was a drachm, and then died at the respectable age of one hundred years.

Post-mortem Appearances.—The morbid appearances are chiefly confined, as is the case with arsenic, to the stomach and bowels; but the corrosive action of the mercurial sublimate is more marked. Inflammation more or less intense is always present in the stomach, the mucous membrane of which may be found of a slate-grey colour, corroded, and so soft as to scarcely admit of the removal of the organ without tearing it. The cæcum and rectum are also sometimes found inflamed, and the mucous membrane softened. Perforation of the stomach is very rare, only one case having been recorded in which this was present. The mouth, throat, and gullet may also present signs of the action of the poison similar to those just described as seen in the stomach.

Fatal Dose.—The smallest dose was *two grains* in the case of a child, but the exact amount to cause death in an adult has not been accurately determined. Recovery has taken place after one hundred grains has been taken.

Fatal Period.—From half an hour to five days. No exact time can be stated. In one case death took place on the twelfth day after swallowing seventy grains of the perchloride.

Treatment.—Vomiting, if present, must be encouraged; if absent, it must be produced by emetics—zinc sulphate or cupric sulphate, followed by copious draughts of warm water. The hypodermic injection of a solution (2 per cent) of apomorphine may also be used to produce vomiting. Albumen, the white of egg, or vegetable glutin produced from flour by washing it in a muslin bag, should be given. The albuminate of mercury so formed should be quickly removed by an emetic, as it is soluble in excess of albumen, and may be digested or absorbed. The rapid removal of the poison from the stomach, however, is the end to which all our exertions must tend. The stomach pump should not be used if it can possibly be avoided, as it may greatly injure the softened mucous membrane of the gullet and stomach. Opium may be given to relieve pain, and opium enemata to relieve purging and tenesmus.

Calomel.

Calomel, or the subchloride of mercury, is not used as a poison. In large doses it may act as an irritant poison, and death has not infrequently occurred even from comparatively small doses. Profuse salivation and gangrene of the mouth have resulted from its use, and cases are recorded of death resulting from these. In many cases idiosyncrasy appears to modify, more or less, the action of this preparation of mercury. The poisonous effect of calomel has been attributed to—(1) Adulteration with corrosive sublimate. (2) Conversion of the calomel into corrosive sublimate by the action of the hydrochloric acid of the gastric juice.

N.B.—The free acid of the gastric juice is probably in too small a quantity to materially alter the composition of the calomel.

Ammonio-Chloride of Mercury.

White precipitate may, if taken in large doses, produce alarming effects, but it cannot be regarded as an active poison. Pavy's experiments on rabbits indicate that it is a more powerful poison than was formerly thought to be the case. Its action is that of an irritant, accompanied with, in some cases, severe salivation.

Red Precipitate.

Red oxide of mercury possesses poisonous properties, but it is seldom employed as a poison. The symptoms most frequently present are vomiting, coldness of the surface of the body, stupor, pain in the abdomen, and cramps of the muscles of the lower extremities. The vomited matters are generally mixed with some of the red oxide.

Cinnabar. Vermilion.

A compound of sulphur and mercury in the form of a dark red crystalline mass is known as cinnabar; and to the same substance reduced to a fine powder the name vermilion has been given. It is used as a red pigment. It can scarcely be considered as a poison, Orfila asserting that it is not poisonous. The vapour of this substance appears, however, to be capable of producing severe symptoms, and in one case, profuse salivation resulted from the application of the vapour to the body.

Cyanide of Mercury.

This substance, though an active poison little inferior to corrosive sublimate, is seldom used as such, probably from its being better known to chemists than to the general public. It differs from corrosive sublimate in having no local corrosive action. It has been supposed, but proof is wanting, that its injurious effects are due to its decomposition by the acids of the stomach and the formation of prussic acid. Death has occurred in nine days from a dose of ten grains. It acts as an irritant. The sulphocyanide of mercury is used in the manufacture of the toy known as Pharaoh's serpents.

Turbith Mineral.

A powerful irritant poison, but seldom used. A drachm has caused death in a boy sixteen years of age. Coldness of the surface, burning pain in the stomach and bowels, with other symptoms of irritant poisoning, were present. After death, the mucous membranes of the throat, stomach, and bowels were found considerably inflamed.

Nitrates of Mercury.

These substances—the nitrate and sub-nitrate—are used in the arts for various purposes. They act as powerful irritant poisons, with symptoms and *post-mortem* appearances not unlike those before described when speaking of corrosive sublimate and other irritants.

Chemical Analysis :—

TABLE SHOWING THE REACTION OF MERCURIC AND MERCUROUS SALTS WITH REAGENTS.

MERCURIC SALTS.

1. With solution of iodide of potassium.	1. Bright scarlet precipitate, soluble in excess.
2. With potash solution.	2. Bright yellow precipitate.
3. With hydrosulphuret of ammonia.	3. First a yellowish and then a black precipitate is produced.
4. Heated in a reduction tube.	4. It melts, boils, is volatilised, and forms a white crystalline sublimate.
5. With ether.	5. It is freely soluble in ether ; and the ethereal solution, when allowed to evaporate spontaneously, deposits the salt in white prismatic crystals.
6. Heated with carbonate of soda in a reduction tube.	6. Globules of metallic mercury are produced.

MERCUROUS SALTS.

1. Hydrochloric acid.	1. A white precipitate of calomel, blackened on addition of ammonia.
2. Potassium iodide solution.	2. Green precipitate.
3. Caustic potash or soda solution.	3. Black precipitate of mercurous oxide.

Detection of Mercury in the Tissues and in the Contents of the Stomach.

Mercury is particularly liable to be absorbed by the tissues ; it also readily combines with various organic substances, gelatine, etc.

A.—If the contents of the stomach are under examination, they should be diluted with distilled water, filtered, and the residue pressed and reserved for further examination.

The liquid thus obtained may be concentrated, and, while still warm, slightly acidified with hydrochloric acid. A slip of zinc foil, with a piece of gold foil twisted round it, is then introduced. If mercury be present, the gold will, sooner or later, lose its yellow colour, and its surface become white and silvery, while the zinc is wholly or partially dissolved. The gold being removed, separated from the zinc, washed first with water and then with ether, is divided into two equal parts. One half may be heated in a reduction tube, when it will yield a sublimate of metallic mercury, identified by the spherical form of the globules under a magnifying-glass, and their metallic reflection and complete opacity. The other half of the gold may be treated with nitric acid and heated, which will dissolve off the mercury. The resulting solution, after expelling the excess of acid by evaporation, will give a scarlet precipitate with iodide of potassium soluble in excess; and, with protochloride of tin, a black precipitate of metallic mercury.

B.—For the detection of mercury in the insoluble form, the residue from *A* is dried; or, if the tissues are under examination, they should be finely divided, and freed from superfluous moisture. In either case, the substance is boiled in moderately strong nitric or hydrochloric acid (about one part of acid to four of water). After digestion for some time, the liquid is filtered, concentrated, and tested as in *A*. When there is reason to infer the presence of corrosive sublimate in considerable quantity in an organic liquid, advantage may be taken of the solubility of the salt in ether, and the power possessed by this liquid of abstracting it from its aqueous solutions. The liquid is agitated with an equal volume of ether, the ethereal solution poured off and allowed to spontaneously evaporate, when the corrosive sublimate will be left in white silky prisms, yielding all the characteristic reactions of the salt. In obscure cases of salivation, the saliva should be examined as follows:—Take about two drachms of the saliva, acidulate with pure hydrochloric acid, and immerse in the mixture a very small piece of copper gauze attached to a platinum wire, and set aside in a warm place for some hours.

If mercury be present, the copper will be covered with a white coating; this should be washed and heated in a reduction tube, when globules of mercury will be formed, and examined with a lens.

C.—Mercury in solution may be detected by Reinsch's process. On boiling with pure copper foil after acidifying the solution with hydrochloric acid, the mercury is deposited on the copper in the metallic state, as a whitish silvery film, which can

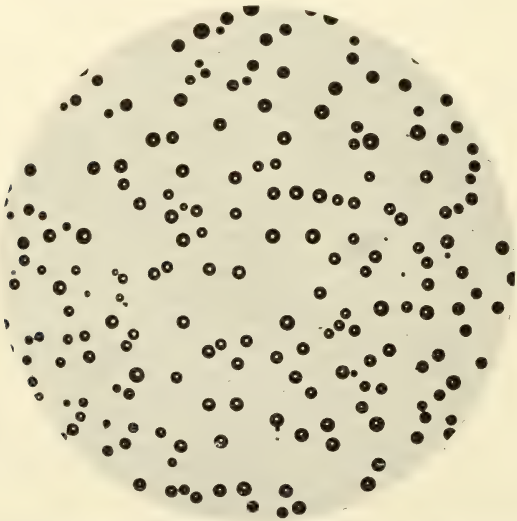


FIG. 30.—Photo-micrograph of globules of mercury obtained by Reinsch's process, ×50. (R. J. M. Buchanan.)

be polished like to a mirror surface. On washing the film in water, ether, and absolute alcohol and allowing it to dry, then subliming it in a reduction tube by the aid of heat, the mercury deposits on the cool part of the tube in the form of minute globules, which may be easily recognised through the microscope. If a small crystal of iodine be now placed in the tube and gently warmed so as to volatilise it, but not the mercury, and the tube be left to stand for a short time, the iodine combines with the mercury to form the scarlet iodide, the colour of which renders it easy of recognition.

According to Bonnewyn, the presence of an extremely small quantity of corrosive sublimate ($\frac{1}{50000}$) in calomel may be detected by immersing a clean knife blade, moistened with alcohol or ether, in the suspected calomel. A black spot is formed on the steel very difficult of removal. No spot is formed when the calomel is pure.

LEAD.

Metallic lead is not poisonous; but it appears probable that when it is acted upon by the acids of the intestinal secretions, it may become so changed as to produce unpleasant symptoms. Any salt of lead is poisonous when in a condition to be absorbed into the system.

Sugar of lead and white lead are alone important, and will therefore be briefly considered.

Sugar of Lead.

Acetate of Lead. Subacetate. Goulard's Extract.

General Character.—The acetate of lead, better known as sugar of lead, is not unlike loaf-sugar in its general appearance. It is usually met with in the form of solid crystalline masses of a white or brownish-white colour. To the taste it is sweet, a metallic astringent taste being left in the mouth. Acetate of lead is soluble in water and in alcohol. The subacetate is a more active poison than the neutral acetate. Sugar of lead is popularly considered as an active poison, but this does not appear to be the case. Sir R. Christison gave eighteen grains daily in divided doses for eight or ten days with no other unpleasant symptoms than slight colicky pains in the abdomen. Lead is probably eliminated from the system by the urine, and also by the milk; but there is reason to believe that when once deposited in the body, some considerable time is required for its complete elimination. Dr. Wilson is of opinion that in chronic lead poisoning the lead is more largely deposited in the spleen than in any other organ of the body. This organ should therefore always be carefully examined in suspected cases of poisoning by this metal.

Goulard's Extract is a solution of the subacetate of lead. It may be of a reddish colour, from the employment of

common vinegar in the place of pure acetic acid in the manufacture.

Goulard's Lotion is the extract diluted with water.

White Lead.

White lead, carbonate of lead, ceruse or kremser white, is used as a pigment. It is generally in the form of white, heavy chalky masses, insoluble in water, and, when taken in large doses, poisonous. It is this substance which, in the majority of cases, causes chronic lead poisoning, or *painter's colic.*

The *chloride* and *nitrate*, the oxides, *litharge* and *red lead*, are all poisonous; but the *sulphate*, due probably to its insolubility, appears to be inert.

Lead poisoning may result from—

1. Constant contact with lead and its salts in manufactories.
2. Its use in the arts and as a pigment. The injurious effects of this substance are strikingly seen among painters, the makers of glazed cards, and the workmen engaged in preparing Brussels lace — this material being whitened by beating white lead into it. All thus employed are liable to suffer more or less from chronic poisoning.
3. Its application to the surface of the body in the form of ointment, plasters, cosmetics, and hair-dyes.
4. Drinking water impregnated with lead, from being stored in leaden cisterns or conveyed in leaden pipes.

"The action of water upon lead is much modified by the presence of saline substances. It is increased by chlorides and nitrates, and diminished by carbonates, sulphates, and phosphates, and especially by carbonate of lime, which, held in solution by excess of carbonic acid, is a frequent ingredient of spring and river water. But water highly charged with carbonic acid may become dangerously impregnated with lead, in the absence of any protecting salt, in consequence of its solvent power over carbonate of lead. In general, water which is not discoloured by sulphuretted hydrogen may be considered as free from lead; but there are few waters which have passed through leaden pipes, or have been retained in leaden cisterns, in which a minute analysis will not detect a trace of the metal; and were it not for the great convenience of lead, iron pipes

and slate cisterns would, from a sanitary point of view, be in all cases preferable.

"Another case of contamination by lead may arise from electric action, as where iron, copper, or tin is in contact with or soldered into lead; and in these cases, owing to the action of alkaline bases as well as of acids upon the lead, danger may occur when it is thrown into an electro-negative as well as into an electro-positive state.

"Cisterns are sometimes corroded and their bottoms are perforated by pieces of mortar having dropped into them, the lime of which has caused the oxidation of the metal and a solution of the oxide."

5. Lead may also find its way into the system by means of the food. Farinaceous foods, chocolate, and tea may become contaminated if lead wrappers be used; and confectionery from the use of lead chromate as a colouring agent. The use of leaden vessels in the manufacture of cider is attended with danger, and also the keeping of pickles in glazed earthenware jars. The celebrated "Devonshire Colic" was the result of cider-making in leaden vats. Beer may be contaminated with lead if allowed to stand in leaden pipes over night. Rum has been known to have been dangerously impregnated with lead, leaden worms having been used attached to the stills. Many tobacconists are in the habit of using lead foil to wrap up their tobacco and snuff; this practice has resulted in several cases of chronic lead-poisoning. Soda and Seltzer waters may contain lead when kept in syphons with leaden caps or valves.

Symptoms of Poisoning by Lead.

Acute.—A metallic taste in the mouth, accompanied with dryness in the throat and intense thirst, is experienced by the patient soon after the poison is swallowed. In some cases, however, *two* or *more hours* may elapse before the effects of the poison begin to show themselves. Vomiting may or may not be present. Twisting colicky pains are felt in the abdomen, relieved in some cases by pressure. The paroxysms of pain may be separated by intervals of ease. The bowels are, as a rule, obstinately confined, and the fæces are of a dark colour, from the formation of the sulphuret of lead. The skin is cold, the pulse quick and weak, and there is considerable prostration of strength. In some cases the patient suffers from cramps of

the calves of the legs, and sometimes, in protracted cases, paralysis of one or more of the extremities may supervene. The effect on the nervous system is marked by a giddiness and stupor, terminating in coma, or convulsions and death.

Chronic.—This form of poisoning generally occurs among painters, manufacturers of white lead, pewterers, and others. The early symptoms are those of ordinary colic, only more severe. The patient generally complains, in the first instance, of feeling unwell, and of general debility. He then suffers from pain of a twisting, grinding nature, felt in the region of the navel. The bowels are obstinately confined. The appetite becomes capricious, and may be entirely lost. The mouth is parched, the breath fœtid, the countenance sallow, the skin dry, and general emaciation sets in. A nasty sweetish metallic taste in the mouth is present in most cases. Not infrequently the subjects of lead poisoning experience a peculiar form of paralysis of the upper extremities, well known as "dropped hand." It appears that this condition is the result of paralysis of the extensor muscles of the wrist. The muscles undergo a form of fatty degeneration. The lead appears to act primarily on the muscles, then on the nerves, and lastly on the nerve centres. One other symptom of importance has yet to be noticed. The gums, at their margins where they join the teeth, present a *well-marked blue line, absent where a tooth has been removed.* This is not present in all cases, but it should be looked for. Cicconardi suggests as a method of diagnosis in lead poisoning, where the cause of the colic is uncertain, to paint the skin with a 6 per cent solution of sodium sulphite. If lead be the cause the painted part will become darkened in colour.

N.B.—The symptoms produced by white lead—carbonate of lead—are those of *colica pictonum*, or *painter's colic*, described under the head of Chronic Lead Poisoning.

Post-mortem Appearances.—In acute poisoning the mucous membrane of the stomach and intestines is inflamed, and is in some cases covered by layers of white or whitish yellow mucus, more or less impregnated with the salt of lead swallowed. Corrosion of the mucous membrane may occur if the dose be large, and this condition is more frequently present when the neutral salt is taken.

In chronic poisoning there are no constant *post-mortem* appearances. The muscles of the paralysed extremity are

usually found flaccid, of a cream colour, and the subject of fatty degeneration.

Fatal Dose.—Sugar of lead is not an active poison, recovery having taken place after one ounce had been swallowed.

Fatal Period.—Uncertain.

Treatment.—The stomach should be emptied by means of the pump or syphon tube, followed by the free administration of the sulphates of soda and magnesia. The carbonates should not be given, the carbonate of lead being poisonous. Vomiting should be promoted, and a powerful cathartic administered. Albumen and milk should also be given, as these precipitate the oxide. In the chronic form of poisoning, the iodide of potash and aperients, notably the sulphate of magnesia, should be administered. Dixon Mann does not consider that iodide of potash is of any value as an eliminator of lead, as the latter forms a stable compound with the tissues. Sulphur baths are also useful in removing the lead from the system. Lately the galvanic bath has been tried with great success. By way of *prophylaxis*, it has been recommended that all those engaged in lead manufactories, or who are obliged to handle this metal frequently, should partake largely of lemonade made with sulphuric acid, should not take their meals in the factories, or without well washing the hands.

Chemical Analysis.—When the solid acetate is heated on platinum foil, it melts, then solidifies, becomes dark in colour and gives off fumes of acetic acid.

The following are the liquid tests for lead in solution :—

1. Dilute sulphuric acid gives a white precipitate of the sulphate, which is insoluble in nitric, but soluble in hydrochloric acid, in excess of caustic potash solution and in ammonium acetate solution.

2. Solution of potassium iodide gives a yellow precipitate, soluble in boiling water and caustic potash solution.

3. Sulphuretted hydrogen, or ammonium sulphide, gives a black precipitate.

4. Potassium bichromate a yellow precipitate.

Detection of Lead in Organic Mixtures.

The contents of the stomach or vomited matters must be diluted with water and filtered. The residue left on the filter, washed with distilled water, should be set aside for further

examination; the filtrate and washings acidified with nitric acid. A current of sulphuretted hydrogen passed through the solution will then throw down the whole of the lead, should any of that metal be present, in the form of a brownish-black sulphide, which may be collected on a small filter and dried. The sulphide, boiled with dilute nitric acid, is partly converted into insoluble sulphate, and in part dissolved as nitrate. The carefully neutralised solution may be either tested at once or carefully concentrated. In either case, the production of a bright yellow precipitate, with a solution of bichromate of potash, and a similar one with a solution of iodide of potassium, may be taken as conclusive of the presence of lead. The portion of lead deposited as sulphate will be found to be soluble in a solution of pure potash, the resulting liquid giving a brown-black precipitate on the addition of sulphide of ammonium.

The insoluble residue left on the filter should be incinerated in a porcelain crucible, either with or without nitric acid, care being taken not to raise the temperature more than is necessary to produce the desired effect: the carbonised mass boiled with dilute nitric acid evaporated to dryness, extracted with distilled water, and then filtered, the filtrate tested as before mentioned. It is often useful, as a preliminary test for the presence of lead in a soluble form, to dip a piece of bibulous paper into the clear liquid obtained by submitting the contents of the stomach or vomited matters to filtration, and then exposing the paper to the action of a current of sulphuretted hydrogen. If lead be present, blackening of the paper will take place.

To detect the lead in the urine and fæces, Dixon Mann advises the urine to be evaporated to the consistency of gruel, and the fæces to be mixed with distilled water to a similar consistence; the organic matters are then to be destroyed with hydrochloric acid and chlorate of potash with the aid of heat, and the solution filtered. The filtrate is then placed in a cell with a parchment bottom, and this into another cell containing distilled water acidulated with sulphuric acid. Two pieces of platinum foil are now placed in the inner and outer cells, separated by the parchment, that in the inner cell is connected with the cathode, that in the outer with the anode of four Grove cells, and the current closed for several hours. The lead if present is deposited on the platinum connected with the cathode.

Recapitulation of the Leading Facts with regard to Poisoning by Lead.

ACUTE POISONING.—SYMPTOMS, ETC.

Action on alimentary canal.	Sweet metallic taste in mouth. Vomiting, constipation, burning twisting pain in the belly. Inflammation of canal.
Circulation . . .	The pulse lowered, and tendency to death from syncope. Anæmia.
Nervous system . .	Neuralgic pain, convulsions, cramps, etc.

CHRONIC POISONING.—SYMPTOMS, ETC.

Mouth and alimentary canal.	Sweet metallic taste; blue line at margins of gums; breath fœtid. Colic, constipation.
Nervous and muscular symptoms.	Headache, delirium, stupor, amaurosis, paralysis of the extensor muscles of the wrist, anæsthesia of the affected part. Fatty degeneration of the muscles.
Circumstances under which it may occur.	Certain trades, as painters, plumbers, type-founders, etc. Action of drinking water on lead. Hair dyes, food in leaden utensils, etc.
Prophylaxis . .	Grinding lead colours in oil or water. Cleanliness in factories. Slate cisterns for water. Dilute sulphuric acid lemonade.
Medical treatment .	Epsom salts, iodide of potassium, galvanic baths, etc.

COPPER.

Metallic copper, like metallic lead, is not poisonous, but its oxides are; it should, therefore, not be swallowed, as it is rapidly acted on by the intestinal secretions and poisonous compounds formed. An alloy of copper is used for ornamenting gingerbread, etc. All the salts of copper are poisonous. The most important are, however, the *sulphate*, *blue-stone*, or *blue vitriol*, and the *subacetate* or *verdigris*.

Copper is eliminated to a slight extent by the urine. It has been found in the stomach, liver, and intestines eight months after its administration had been discontinued. It has also been detected more readily in the bronchial secretion than in the urine.

Symptoms of Poisoning by Copper.

Acute.—The primary action of the sulphate of copper in from five- to fifteen-grain doses is that of a quick emetic; in larger doses, a powerful irritant; but when absorbed, it appears to act chiefly on the brain and nervous system. Its irritant action is marked by nausea, vomiting, griping pain in the belly, which is greatly distended, and increased flow of saliva. The vomited matters are of a bluish or greenish colour, and the discharges from the bowels greenish and containing blood. The vomited matters become blue on the addition of ammonia. The above-mentioned symptoms usually follow immediately after the poison is swallowed, and rapidly increase in severity. After a time, the remote effects supervene, marked by headache, giddiness, laboured breathing, quick irregular pulse, coma or convulsions, paralysis, and death.

In poisoning by this substance, the convulsions are most violent, and wild incoherent delirium not infrequent.

The subacetate of copper or verdigris produces symptoms not unlike those just described. Jaundice and suppression of urine may result when either this or the sulphate is taken.

Chronic.— Constant and troublesome irritation of the stomach and bowels; vomiting and purging, attended with considerable straining at stool; loss of appetite, loss of power, and general emaciation set in. The patient is subject to frequent trembling of the limbs, which may end in paralysis. The mouth is unpleasant, and a coppery metallic taste is experienced. Cramps or colicky pains in the belly are not infrequently present. Jaundice is sometimes present. The vomited matters are greenish; but the practitioner must not be led away, and thus mistake the colour of the vomited matters which occur in some morbid states of the bile for that the result of poisoning by a salt of copper. A form of chronic poisoning affecting workers in this metal has been described by some French pathologists as "copper-colic." A cachectic condition of the system, accompanied with one or more of the symptoms already detailed, marks this form of poisoning. A *purple* line along the margins of the gums is present in some cases.

Copper poisoning may result from—

1. Its introduction into the system by using, for culinary purposes, copper vessels not properly tinned. An interesting account of poisoning from this source may be found in the

second volume of the *Medical Observations and Inquiries by a Society of Physicians in London*, published 1764. The cases there recorded occurred on board ship, with most alarming symptoms.

2. By constant application of the metal to the surface of the body, necessitated by certain processes in its manufacture and in its application for industrial purposes. M. Michel Lévy, however, says in his work, *Traité d'Hygiène, Publique et Privée*, that workmen in copper may pass green-coloured urine and yet be as robust and as long-lived as other workmen.

3. The use of certain preparations of this metal as pigment.

4. The use of German silver—an alloy of copper, zinc, and nickel—may be rendered dangerous by the action of acid food upon the compound.

5. The use of a salt of copper to give a green fresh colour to certain tinned vegetables and fruits, peas, etc., now introduced into this country from France.

Post-mortem Appearances.—The mucous membrane of the stomach is inflamed, the inflammation extending sometimes into the gullet. The intestines may be found perforated. The lining membrane of the whole alimentary canal presents a deep green colour, distinguished from that the result of a morbid condition of the bile by being turned blue on the addition of ammonia.

Fatal Dose.—Nothing certain is known as to the exact quantity that may prove fatal, as the evidence of the poisonous action of copper is somewhat contradictory. It appears to be more dangerous in small doses than in large ones. Half an ounce of verdigris or subacetate has proved fatal to an adult.

Fatal Period.—The shortest time on record is four hours

Treatment.—Induce vomiting, and assist the emetic action of the copper salts by the free use of warm water, milk, or any demulcent drink. The stomach tube may be used if vomiting do not occur. As an antidote, large quantities of albumen and iron-filings have been given, of which the former appears to be most efficacious.

Chemical Analysis.—The following are the liquid tests for copper in solution :—

1. Ammonia gives a bluish-white precipitate soluble in excess, forming a blue solution.

2. Sulphuretted hydrogen and ammonium sulphide give a chocolate-coloured precipitate

3. Ferrocyanide of potassium gives a port-wine colour, or reddish-brown precipitate.

4. If a bright steel needle be introduced into an acid solution of copper, the metal is deposited on the needle.

5. If a piece of zinc bound with platinum wire be placed in a solution of a copper salt, the metal is deposited on the platinum; it is turned violet on exposure to the vapour from sulphuric acid mixed with potassium bromide.

Detection of Copper in Organic Liquids.

A.—The finely-divided tissue, or the contents of the stomach, diluted with water, are thrown on a filter, and the insoluble portion set aside for further treatment. (See *B.*)

The filtrate and washings may now be concentrated, acidified with sulphuric acid, and a polished needle inserted in the liquid; and should no immediate deposition of metallic copper occur, it may be allowed to remain for several hours. The colour of the metallic deposit is highly characteristic of copper. As a corroborative proof, the concentrated liquid may be placed in a platinum capsule with some fragments of zinc, when the copper will be deposited on the platinum capsule at the parts in contact with the zinc; the liquid poured off, and the excess of zinc adhering to the platinum removed by dilute hydrochloric acid. The copper may now be dissolved off the platinum by nitric acid, the excess of acid driven off by heat, and the solution subjected to the wet tests given above.

B.—The insoluble portion from *A* is incinerated in a porcelain crucible. The ash thus obtained is digested in hydrochloric acid with the aid of heat, and evaporated nearly to dryness. The residue, dissolved in distilled water, may be tested as under '*A*.'

ZINC.

The sulphate and the chloride of zinc are alone important. Poisoning by the chloride of zinc has been described (p. 286).

Sulphate of Zinc.

White vitriol or white copperas.

Symptoms.—The sulphate of zinc acts as a pure irritant. Violent vomiting, accompanied with pain in the abdomen, and purging, are the symptoms which first make their appearance.

These may be followed by symptoms which betoken collapse, viz. coldness of the limbs, paleness of the face, irregular pulse, and fainting.

Post-mortem Appearances.—Presence of inflammatory action.

Fatal Dose.—Uncertain.

Fatal Period.—Death has occurred in four hours.

Chemical Analysis.—Distinguished from oxalic acid by remaining fixed when heated on platinum foil.

In Solution :—

1. *Ammonia* gives a white precipitate soluble in excess.
2. *Ferrocyanide of Potassium*, a white precipitate.
3. *Sulphuretted Hydrogen*, a milky-white precipitate in a neutral pure solution.
4. *Nitrate of Baryta*, a white precipitate showing the presence of sulphuric acid.
5. *Caustic potash* or *soda*, a white precipitate soluble in excess.

In Organic Mixtures pass sulphuretted hydrogen, collect the sulphuret, and decompose it with boiling hydrochloric acid, then test for zinc.

Treatment.—Tea, coffee, milk, warm water, albumen, and in some cases enemata of gruel and other emollients.

IRON.

The preparations of iron which are of importance are the sulphate and the muriate.

Sulphate of Iron.

Copperas or *Green Vitriol*—has been administered as a poison, but more frequently to procure abortion. An ounce has been taken with no other serious effect than the production of violent pain, purging, and vomiting. Constant application of this substance to the body has produced vomiting, pains in the belly and limbs. These symptoms disappear on treatment.

Chemical Analysis.—(1) Hydrosulphuret of ammonia gives a black precipitate. (2) Ferrocyanide of potassium added to it, in solution, gives rise to a greenish-blue precipitate, becoming dark blue on exposure. (3) Chloride of barium will point to the nature of the acid present.

Muriate of Iron.

Better known as the *Tincture of Sesquichloride of Iron*, or

the *Tinctura Ferri Perchloridi.*—The tincture acts as a corrosive and irritant poison, death having followed in five weeks after an ounce and a half had been swallowed. Recovery has, however, taken place after three ounces had been swallowed. The symptoms present in most cases observed were those of a corrosive and irritant.

Chemical Analysis.—(1) The addition of nitrate of silver, causing a white precipitate insoluble in nitric acid, points to the presence of chlorine. (2) The peroxide of iron, indicated by the formation of Prussian blue on adding a solution of the ferrocyanide of potassium.

BISMUTH.

The preparations of this metal act as irritant poisons, death having occurred from a dose of two drachms of the subnitrate. Dr. Trail (*Outlines of Medical Jurisprudence*, p. 116) mentions the case of a patient of his who took *six drachms* in three days in divided doses. The symptoms were vomiting, extreme pain in the abdomen and throat, a weak, feeble pulse, and much anxiety about the præcordia. Recovery took place. Not long ago, in Scotland, a case of severe vomiting during pregnancy, ending fatally, was mistaken for arsenic poisoning. The error arose from mistaking a greyish powder on the walls of the stomach for arsenic. It turned out on further inquiry that it was bismuth, given medicinally to prevent the vomiting.

POTASSIUM.

Nitrate of Potash.

This substance is well known as nitre, saltpetre, and sal prunella. In large doses it acts as an irritant, and cases are recorded in which it has been used to poison children. In one case, the presence of crystals of the salt in some of the dried vomited matter on the child's shoe, led to an explanation of the cause of death.

Symptoms.—Those of a pure irritant, to which death must be referred, and not to any constitutional action of the drug. The nervous symptoms, which are sometimes very marked, are, as is well known, common to the action of many pure irritants. In some cases there is suppression of urine.

Post-mortem Appearances.—Those produced by irritants generally

Chemical Analysis.—Separate the poison by dialysis, evaporate, and test the crystals as directed under nitric acid.

Fatal Dose.—About an ounce.

Fatal Period.—Two hours.

Treatment.—The same as for other irritants; demulcent drinks. Promote vomiting.

Sulphate of Potash.

Sal Polychrist, *Sal de Duobus*, or sulphate of potash, acts as an irritant poison, being largely used in France as an abortive. The symptoms and the *post-mortem* appearances are much the same as those produced by the nitrate. A like treatment may also be adopted. In the detection of this substance, the nitrate of baryta will point to the acid present, and bichloride of platinum to the presence of potash.

Chlorate of Potash.

This salt acts as a poison when taken in large doses, producing symptoms which might be mistaken for poisoning with arseniuretted hydrogen, or for such diseases as hæmoglobinuric fever.

Symptoms.—These comprise pain in the stomach and bowels with vomiting, collapse and stupor, cyanosis, jaundice; diminution of the urine, which contains hæmoglobin, casts, and albumen. It is a question whether the jaundice is hæmatogenous or hepatogenous. Chlorate of potash destroys the red corpuscles, the hæmoglobin is dissolved out and is set free in the liquor sanguinis.

Fatal Dose.—45-50 grains proved fatal to a child three years old. For an adult 390 grains to an ounce and a half.

Fatal Period.—From five hours to several days.

Treatment.—The stomach should be washed out through the syphon tube. Venæsection may be useful, with subsequent transfusion of fresh blood. The nephritis and other symptoms must be treated generally.

Post-mortem Appearances.—The mucous membrane of the stomach may be inflamed and submucous hæmorrhages may be found. The blood is chocolate in colour and gives the spectrum of methæmoglobin. The spleen is enlarged and chocolate-coloured, and the kidneys acutely inflamed.

Chemical Analysis.—Chlorate of potash may be separated from organic material by dialysis.

1. If to a solution of the salts a few drops of indigo sulphate be added, and then a few drops of strong sulphuric acid, the indigo-blue is bleached.

2. If a small crystal of the chlorate be heated in a test tube with a drop of strong sulphuric acid, it explodes with detonation.

BARIUM.

The chloride, nitrate, and carbonate of barium are all irritant poisons. But besides their irritant action, the salts of barium also appear to act on the nervous system and the heart, arresting its action in systole. The symptoms, *post-mortem* appearances, and treatment are the same as for the other irritant poisons. Sulphate of magnesia, or other soluble sulphate, should be given to form an insoluble sulphate of baryta.

Chemical Analysis.—Sulphuric acid or alkaline sulphate gives a white precipitate with solution of chloride of baryta, insoluble in nitric acid. The salts impart to flame a greenish-yellow colour. The chlorine is detected by nitrate of silver. Dissolve the carbonate in hydrochloric acid, and test as above.

CHROMIUM.

Two compounds of this metal are largely used in the arts for dyeing purposes—the neutral chromate and the acid bichromate of potash. The bichromate of potash is a powerful poison, and death may occur from its direct action on the nervous system, without the development of any of the signs of irritation; in other cases, however, well-marked irritant symptoms have been present. Applied externally, it produces deep fistulous sores, especially on the mucous membrane of the septum of the nose, in the workmen who are engaged in its manufacture. These sores are prevented to some extent by taking snuff. Dyers not infrequently suffer severely on their arms when using it in the course of their trade. Death has resulted in *four hours* after its administration.

Chemical Analysis.—A solution of the bichromate of potash, added to a solution of acetate of lead, gives a yellow precipitate; with nitrate of silver, a red. The salt boiled with hydrochloric or sulphuric acid and alcohol, gives a green liquid.

Treatment.—Emetics, magnesia, chalk, demulcent drinks, etc.

CHAPTER V.

VEGETABLE AND ANIMAL IRRITANTS.

Mode of Action.—The general effects produced by the somewhat large class of vegetable irritants are—

1. Severe abdominal pain, accompanied with vomiting and purging.

2. Absence in most cases of any cerebral or nervous symptoms.

3. The irritant properties appear to reside in an acrid oil or resin. In colchicum, stavesacre, and some others, the presence of an alkaloid may account for their active properties.

4. In medicinal doses, the vegetable irritants act as safe purgatives.

5. The *post-mortem* appearances found in the alimentary canal betoken inflammation, the result of irritation.

6. Applied externally, they produce inflammation, pustular eruptions, and sometimes unhealthy callous sores.

SAVIN.

The leaves and tops of this plant, *Juniperus Sabina* (*N. O. Coniferæ*), yield an acrid volatile oil, to the presence of which the poisonous properties are due. The oil is colourless or pale yellow, with a peculiar terebinthinate odour. It is used in medicine both internally and externally, and is supposed to possess emmenagogue properties. The dried powder is less active than the fresh tops. Savin is seldom used as a poison, more frequently to procure abortion. Its use for this purpose is mentioned in the old ballad of "Marie Hamilton":—

> The King has gane to the Abbey garden,
>   And pu'd the savin tree,
> To scale the babe from Marie's heart;
>   But the thing it wadna be.

Symptoms.—Those of irritant poisoning. Violent pain in the abdomen, followed by vomiting, and in some cases salivation and strangury. Purging is not always present. When taken to procure abortion, death often takes place before the object for which it was taken is attained.

Post-mortem Appearances.—The stomach, gullet, and intestines are found congested and inflamed. The stomach may in places be seen corroded, and a green powder adherent to its coats. The powder washed and dried, and then rubbed, gives off the odour of savin.

Chemical Analysis.—When an infusion or decoction of the leaves has been taken, chemical analysis is of no assistance. The oil may be separated from the contents of the stomach by subjecting them to distillation, and then shaking the distillate with ether, when the oil is dissolved out. On the evaporation of the ether, the oil is left for examination. When the powder is taken the contents of the stomach are not unlike green pea-soup. If a small portion of the green liquid be taken, and diluted with water, the green chlorophyll, being insoluble, will sink; but if the colour be due to bile, the liquid will remain of a uniform green colour. If a portion of the green matter be collected, dried, and then rubbed in a mortar, the characteristic odour of savin will be given off. The microscope may detect bits of the twigs.

The oil, on the addition of strong sulphuric acid, gives a brown colour. On diluting the coloured liquid with water, a dense white precipitate forms.

CROTON OIL.

The oil expressed from the seeds of *Croton tiglium* (*N. O. Euphorbiaceæ*).

The seeds, when taken, produce violent pains in the stomach and purging. Pereira has described the case of a man who suffered severely from inhaling the dust of the seeds. The dose of the oil is from half a minim to a minim. Dr. Trail mentions the case of a delicate lady patient who took three drops for a dose without inconvenience. Dr. Adam records a case (*Edinburgh Medical Journal*, 1856) of a man who, in mistake, drank three drachms of a liniment containing about fifty drops of croton oil. After the most alarming symptoms, the patient ultimately recovered. Two drachms and a half have caused death (*Journal de Clinic Medicale*, 1839, p. 509).

The poisonous properties depend upon the presence of a fatty acid.

A medical friend informs me that in Shetland six drops in as many colocynth pills have, in cases there, only produced "a comfortable '*aisement*' of the bowels." This is attributed to the *dura ilia*, resulting from a constant fish diet.

Symptoms.—Pain in the abdomen, vomiting, and purging, followed by exhaustion and collapse. In some cases, when the dose is large, the pain is hot and burning, and may be felt from the mouth downward.

Chemical Analysis.—Separate the oil from the contents of the stomach by means of ether, and then drive off the ether by means of heat. The oil then warmed with nitric acid becomes of a brown colour, and nitrous acid vapours are given off.

COLCHICUM.

The poisonous properties of *Colchicum autumnale*, Meadow Saffron (*N. O. Melanthaceæ*) reside in an alkaloid *Colchicine*, chiefly found in the corms, but also present in other parts of the plant. The seeds have caused death.

In June 1875 an epidemic of gastric irritation among the inhabitants of Rione Boego was traced to the use of the milk of goats which had accidentally eaten the leaves of colchicum.

Symptoms.—Colchicum, in medicinal doses, increases the activity of the liver, and bile is freely secreted. The action of the kidneys and of the skin is also increased. The heart is more or less affected, and its frequency diminished. In large doses, all the symptoms of irritant poisoning are present, and in some cases have been likened to those observed in Asiatic cholera.

Post-mortem Appearances.—Death may result from its use without leaving any morbid appearances. In other cases, however, the usual signs of inflammation were present. Casper describes the colour and condition of the blood in those poisoned by colchicum as dark cherry-red, with the consistency of treacle. A marked congestion of the vena cava may also be present.

Chemical Analysis.—Colchicine, obtained by Stass' process, added to concentrated nitric acid, becomes of a violet colour, changing to blue and brown. The violet solution changes to yellow on dilution with water, then to red on adding caustic

soda. Tincture of iodine precipitates colchicine of a kermes brown colour, platinum bichloride yellow, and tannic acid white, the precipitate being soluble in alcohol, acetic acid, and alkaline carbonates. Strong sulphuric acid gives a yellow colour with colchicine, which changes to green, violet, and reddish-brown on the addition of nitric acid.

Fatal Dose.—One ounce of the tincture.

Treatment.—Stimulants and opium should be given to counteract its depressing effects. Tannin is said to be an antidote.

ERGOT.

Like savin, ergot is more frequently used to procure abortion than as a poison. When taken in a large dose it causes vomiting, purging, intense thirst, hurried breathing, and irregularity of the heart's action. Ergot appears to act powerfully on non-striated muscular fibre wherever it exists in the body; hence the vessels contract powerfully, and the peristaltic action of the intestinal canal is greatly increased. On the pregnant uterus its action is uncertain, as it does not appear to have any marked power in inducing labour, but on the parturient uterus its effects are most marked. A case is recorded in the *Lancet* (vol. ii. 1882) in which ergot had been taken for some time to procure abortion, but this end not being accomplished, the patient took "two hands full" of the powdered ergot to expedite matters, which caused the following fatal symptoms:—There was some amount of jaundice, and the expression of the face was anxious. Occasionally fits of stupor occurred, and the general condition of the patient was maudlin, but there was no smell of alcohol in the breath; but during the course of the case, which ended fatally, a distinct etherish smell could be perceived. The pulse was so quick that it could not be counted, and it had also a peculiar jerky feel under the finger. Attempts were made to induce labour by passing a *bougie-a-boule*, but the patient died collapsed before delivery could be effected.

Where the drug has been taken for some time in the form of rye-bread made from the diseased grain, the symptoms in some cases are referable to the nervous system; in others, the blood appears to undergo certain changes; and hæmorrhages into the internal organs, as in the case just mentioned, have

been frequently noticed. Gangrene of one or more of the extremities has also been known to occur. To chronic poisoning by this drug the term *Ergotism* has been applied, and may occur under two forms—the spasmodic and the gangrenous; the former marked by convulsions, giddiness, delirium, dimness of vision, and tetanic spasms; the latter, as a rule, by dry gangrene of the nose or extremities.

Chemical Analysis.—Ergot has a peculiar, slightly fishy odour, which is increased by rubbing up the powder with liquor potassæ and heating the mixture. At the same time it turns a reddish colour. The production of this odour, and the appearance under the microscope, are the only tests yet known for this substance in powder. From organic mixture it may be extracted with hot alcohol acidulated with sulphuric acid. The solution is red in colour, and shows two bands in the spectrum, one in the green, and a second, broader and more marked, in the blue.

Treatment.—Wash out the stomach, and give inhalations of amyl nitrite.

BLACK HELLEBORE.

This plant, *Helleborus niger*—Black Hellebore—(*N. O. Ranunculaceæ*), known as the Christmas rose, is the melampodium of the old pharmacopœias. All parts of the plant are poisonous.

Symptoms.—Purging, vomiting, pain in the bowels, and cold sweats. Death is generally preceded by convulsions and insensibility.

Post-mortem Appearances.—Those common to the action of other irritants.

WHITE HELLEBORE.

White Hellebore, *Veratrum album* (*N. O. Melanthaceæ*), acts very much in the same manner as the black hellebore, but is more powerful. The powder causes violent sneezing. The alkaloid *Veratria* appears to be the active principle. The symptoms and *post-mortem* appearances are analogous to those produced by black hellebore.

GAMBOGE.

Gamboge is the gum resin of *Garcinia Morella*. It is an active ingredient in certain quack "vegetable pills." One

drachm has caused death by its irritant action. Owing to the imperfect pulverisation of gamboge in quack pills, they have caused violent irritation of the bowels, straining at stool, and prolapsus uteri, due to the irritating action of small pieces of this substance.

JALAP.

Jalap, the powder obtained from the tubers of *Exogonium Purga.* The active properties of the drug reside in a resin. It is a drastic purgative ; twelve grains have killed a dog.

SCAMMONY.

Scammony is obtained from the dry root of *Convolvulus Scammonia.* Like the last mentioned, it is a powerful purgative, and may cause death if given in large doses to debilitated individuals.

CASTOR-OIL.

The oil expressed, with or without the aid of heat, from the seeds of *Ricinus communis.* A girl, eighteen years of age, died in Liverpool in 1837 from eating a few of the castor-oil seeds.

ARUM MACULATUM.

Cuckoo-pint, Wake-robin, or Lords and Ladies, is one of the most acrid of indigenous vegetables. The active property of the plant appears to be lost by drying, and by distillation in water. Children have been poisoned by its leaves.

YEW.

The twigs and fruit of *Taxus baccata* act as irritant poisons, producing also symptoms which point to cerebro-spinal mischief. A case is recorded of poisoning by yew leaves, in which only five grains of the leaves were found in the stomach ; yet death took place within an hour from the time the symptoms commenced (*British Medical Journal*, 1876, vol. ii. p. 392). In the above-mentioned case, vomiting and other signs of gastric irritation were absent. The chief symptoms present were—pallor of the face, faintness, an almost imperceptible pulse, facial convulsions, foaming at the mouth, stertorous breathing, loss of consciousness, ending in death. Several children have died after eating the fruit. *Post-mortem* signs of irritation of the alimentary canal.

LABURNUM.

Cytisus Laburnum, or common Laburnum, the seeds, bark, and wood of which are poisonous. They contain a narcotico-acrid, crystallisable alkaloid — *Cytisine* — producing vomiting, foaming at the mouth, convulsions, and insensibility. Recovery took place in two cases mentioned by Trail, from the use of emetics and ammonia.

FOOL'S PARSLEY.

Æthusa Cynapium has been mistaken for parsley. Nausea, vomiting, giddiness, and severe abdominal pains are among the most common symptoms of poisoning by this plant.

BRYONY.

Two plants are included under this name, *Bryonia dioica*, white bryony (*N. O. Cucurbitaceæ*), the only indigenous cucurbitaceous plant, and the *Tamus communis*, black bryony (*N. O. Dioscoreaceæ*). Both the bryonia dioica and the tamus communis possess active irritant properties. They are of importance from the fact of their growing wild, and the possibility of the fruit being eaten by children.

ELATERIUM.

Elaterium, the inspissated juice of *Ecballium officinarum*, or Squirting Cucumber. It is a powerful drastic purgative, one grain having given rise to alarming symptoms in man.

ANIMAL IRRITANTS.

CANTHARIDES.

Cantharides—*Cantharis vesicatoria* (*N. O. Coleoptera*)—is seldom given as a poison, but is most frequently employed to procure abortion, or for its supposed aphrodisiac properties.

Cantharides is a pure irritant. Applied externally, it produces vesication ; and if absorbed, strangury.

Cantharidine—the active principle of Cantharides—is insoluble in water and bisulphide of carbon. It is but slightly soluble in alcohol, but it is dissolved by chloroform, ether, and

some oils. Four parts of cantharidine have been procured from a thousand parts of the flies.

Symptoms.—An acrid taste is first experienced in the mouth, followed by a burning heat in the throat, stomach, and abdomen. There is constant vomiting of bloody mucus, and the stools also contain blood. The patient complains of intense thirst, pains in the loins, and an incessant desire to void urine, which is frequently mixed with blood. Salivation in some cases is a prominent symptom. Strangury may result from the external application of cantharides as a blister, etc. Priapism is often obstinate and painful, and the fatal termination is generally ushered in by violent convulsions and delirium. In pregnant women, abortion may take place as a result of the general irritation and disturbance of the system, there being no proof that the uterus is particularly affected by the drug. The vomited matters may contain shining green particles, the presence of which indicates the nature of the poison taken. The invasion of the symptoms may in some cases be retarded.

Post-mortem Appearances.—Those of powerful irritation. The mucous membrane of the whole alimentary canal, from the mouth to the rectum, has been found in a state of acute inflammation. The uterus, kidneys, and internal organs of generation share also in the general irritation, ulceration of the bladder having been met with in some cases. Portions of the wings and elytra are sometimes found adhering to the coats of the stomach.

Fatal Dose.—One ounce of the tincture has caused death in fourteen days. This is perhaps the smallest fatal dose on record. Six ounces have been stated to have produced no dangerous symptoms. The worthlessness of the preparation may account for this result.

Treatment.—Vomiting should be promoted and warm mucilaginous drinks given. If vomiting be absent, emetics should be administered. Oil should not be given, as it dissolves out the active principle. Opium may be given with advantage.

Chemical Analysis.—The contents of the stomach should be concentrated and then treated with chloroform, filtered, and the filtrate allowed to spontaneously evaporate. A portion of the residue should then be placed on the skin, and the presence or absence of vesication noticed. Examined under the microscope,

portions of the wing-cases may be detected. No change of colour is produced in cantharidine by the action of sulphuric or nitric acid, thus distinguishing this substance from any of the vegetable alkaloids.

PUTREFACTIVE OR BACTERIAL ALKALOIDS.

The processes by which complex and highly organised substances are broken up into their primary elements are largely synthetical. The putrefactive processes brought about by the action of bacteria result in the formation of special products, some of which combine with certain mineral and vegetable acids to form definite chemical salts; in this respect they correspond with inorganic and organic bases. These products are called ptomaines, a name suggested by an Italian toxicologist, Selmi, and it is derived from the Greek word $\pi\tau\hat{\omega}\mu\alpha$, a cadaver or corpse.

On account of their basic properties, resembling the vegetable alkaloids, they are called putrefactive or bacterial alkaloids. They have been called animal alkaloids, but some ptomaines may be produced by the action of bacteria upon vegetable proteids; so this term is not strictly applicable, and should be restricted to those basic bodies or "*leucomaines*" that result from metabolism of the tissues in the animal body.

The essential element of their basic nature is nitrogen, and in this they resemble the vegetable alkaloids. Some contain oxygen, like the fixed alkaloids, while others do not, like the volatile alkaloids nicotine and conine. The kind of ptomain formed depends upon the nature of the bacterium, the material upon which, and the conditions under which, it grows; the amount of oxygen present; the temperature and the period of growth. All ptomaines are not necessarily poisonous. Albumin is the origin from which all alkaloids, vegetable or animal, are derived. The following is a list of the principal ptomaines:—

Methylamine, CH_3NH_2.—Found in herring brine and decomposing fish—non-poisonous.

Dimethylamine, $(CH_3)_2NH$.—From putrefying gelatine, yeast, fish, and sausage—non-poisonous.

Trimethylamine, $(CH_3)_3N$.—Various decomposing animal and vegetable tissues, ergot—poisonous in large quantities.

Ethylamine, $C_2H_5NH_2$.—Beet-sugar, wheat-flour—non-poisonous.

Diethylamine, $(C_2H_5)_2NH_2$.—Putrid fish and sausage—non-poisonous.

Triethylamine, $(C_2H_5)_3N$.—Putrid fish and sausage—non-poisonous.

Propylamine, $C_3H_7NH_2$.—From cultures of bacteria of fæces—non-poisonous.

Butylamine, $C_4H_{11}N$.—From cod-liver oil. Diaphoretic and diuretic—in large doses causes vomiting and stupor.

Iso-amylamine, $(CH_3)_2.CH.CH_2CH_2NH_2$.—Decomposing yeast and cod-liver oil—active poison, causes convulsions and death.

Caproylamine, $C_6H_{15}N$.—Called septicin by Hager.

Collodine, $C_8H_{11}N$.—The first ptomain obtained in a chemically pure condition—from putrid horse flesh, pancreas, gelatine, and mackerel.

Hydrocollodine, $C_8H_{13}N$.—Putrefying horse flesh and mackerel—highly poisonous.

Parvoline, $C_9H_{13}N$.—Putrid horse flesh and mackerel.

Unnamed base, $C_{10}H_{15}N$.—From decomposing fibrin and jelly-fish. Like curare in its action.

Putrescine, $C_4H_{12}N_2$.—From human corpses—feebly poisonous.

Cadaverine, $C_5H_{16}N_2$.—From human corpses—causes suppuration.

Neuridine, $C_5H_{14}N_2$.—Common product of putrefaction—quite inert.

Neurine, $C_5H_{13}NO$.—From human corpses, intensely poisonous—resembles muscarin in its action.

Choline, $C_5H_{15}NO_2$.—From putrefying animal and vegetable substances—feebly poisonous; by giving up one molecule of water it changes to neurine—this may be brought about by bacteria or chemical agencies.

Muscarine, $C_5H_{13}NO_2$.—From putrid fish and horse flesh. The active principle of poisonous mushroom.

Gadinine, $C_7H_{16}NO_2$.—From putrefying codfish, haddock, and gelatine, in pure cultures of proteus vulgaris—poisonous in large quantities.

A Base (?), $C_7H_{17}NO_2$.—From decomposing horse flesh—its action is like curare: causes loss of temperature, rigors, convulsions, and general paralysis; the heart stops in diastole.

Mydaleine.—Composition not determined—from human corpses—actively poisonous.

Even after prolonged periods and with access of air any putrefactive alkaloids which may form do so in very small quantities, and they are very unstable. In their chemical reactions they respond to many of the group-tests used for alkaloids, but they differ in their reaction to the special tests used for vegetable alkaloids. There is no test that will differentiate between putrefactive and vegetable alkaloids, as a class; at the same time no putrefactive alkaloid will give the same chemical reactions, and have the same physiological properties, as any one of the vegetable alkaloids.

Neurine was first obtained by Liebreich by boiling protagon with concentrated baryta. Since then it has been extracted from putrefying animal tissues. The free base is strongly

alkaline, and gives a white cloud with the vapour of hydrochloric acid. It is intensely poisonous, resembling muscarine in its action. Very small quantities cause complete paralysis in frogs. Respiration ceases first, and the heart-beats become more and more feeble, until it stops in diastole. If atropine be now injected the heart begins to beat again.

As a defence set up in cases of poisoning, when one or other of the rarer alkaloids has been used, it has been suggested that the poison discovered in the body of the deceased was due to the processes of putrefaction of the tissues themselves. In view of this it is important to know the toxic power of such putrefactive alkaloids as may be found in the human cadaver.

Two only of these are actively poisonous—*neurine* and *mydaleine;* others are toxic in so small a degree that large amounts would be required to produce lethal effects, far more in proportion to the body weight than any vegetable alkaloid for which it may be alleged they have been mistaken.

Neurine does not appear before the fifth or sixth day after death, *mydaleine* not until the seventh day, and only in traces; it does not appear in amount sufficient for quantitative analysis until the end of the second or third week.

At the period after death when a medico-legal analysis has generally to be made, *choline* is the only alkaloid present, and it is but feebly poisonous.

In rabbits *neurine* causes marked salivation and increased flow of secretion from the eyes and nose. The heart beats more quickly at first, but gradually slows down and stops in diastole. There is increased peristalsis of the intestines with profuse diarrhœa. There is narrowing of the pupil both after injection or local installation. Clonic spasms and violent convulsions occur, and are followed by paralysis first of the hind then of the fore legs, ending in death. The symptoms are prevented or relieved by atropine.

If atropine be injected first the poisonous effects of the *neurine* do not show themselves.

Mydaleine was discovered by Brieger in putrefying cadaveric organs. Small doses injected into guinea-pigs cause profuse lachrymation and coryza.

The pupils dilate and then become motionless. The temperature rises from 1° to 2° Centigrade. There is somnolence

at this stage, with increased intestinal peristalsis. The pulse and respirations are quickened; later these with the temperature return to the normal, and the animal recovers. Large doses cause death with the heart in diastole and the intestines contracted.

Clonic spasms and stupor precede death.

The Extraction of putrefactive alkaloids from organic matters may be carried out by the process for alkaloid extraction (*vide* pp. 372 *et seq.*).

Amongst the attempts made to distinguish the putrefactive from vegetable alkaloids by chemical reactions one method was based on the rapid reduction of potassium ferricyanide to the ferrocyanide. After converting the alkaloid to a sulphate, a solution of it is mixed with a drop of potassium ferricyanide and a drop of ferric chloride added: the deep blue colour of Prussian blue is produced if reduction to the ferrocyanide has taken place. However, certain vegetable alkaloids, viz. morphine, aconitine, eserine, and hyoscyamine act rapidly as reducing agents upon the ferricyanide. Emetine, igasurine, nicotine, colchicine act less rapidly. Brieger considers that when the reaction occurs with putrefactive alkaloids it is due to impurities present in them. Brouardel and Boutmy have suggested making use of the action of alkaloids upon photographic silver bromide paper as a means of distinction. The paper is written upon with a solution of the alkaloid and kept light free for half an hour; it is then fixed in a solution of sodium hyposulphite and washed in water. The putrefactive alkaloids are said to reduce and blacken the silver compound, while the vegetable alkaloids do not. Neither of these processes is to be relied upon for medico-legal purposes.

LEUCOMAINES OR ANIMAL ALKALOIDS.

Leucomaines or *animal alkaloids* are basic substances which originate from the metabolic processes taking place in the animal body. They closely resemble the vegetable alkaloids, and some are found in plants as well as animals. It is probable that some of them may have originated primarily from the putrefactive processes in the intestines and been absorbed into the system. The following is a list of the principal leucomaines resulting from the metabolism of the tissues of the animal body:—

Adenin, $C_5H_5N_5$.—From thymus gland, from all tissues animal or vegetable which are rich in nucleinic acid—poisonous in large doses.

Sarkine or *hypoxanthine*, $C_5H_4N_4O$.—From urine and flesh—causes increased reflex excitability and convulsive seizures.

Guanine, $C_5H_5N_5O$.—From flesh and guano—it is inert.

Xanthine, $C_5H_5N_4O_2$.—From flesh and urine—acts as a muscle stimulant.

Heteroxanthine, $C_6H_6N_4O_3$.—From urine.

Methylxanthine, $C_6H_6N_4O_2$.—From urine.

Paraxanthine, $C_7H_8N_4O_2$.—From urine—destroys spontaneous muscular action, lessens reflex excitability.

Carnine, $C_7H_8N_4O_3$.—From fresh meat.

Gerotine, $C_5H_{14}N_2$.—From liver and kidneys, an isomer of cadaverine—exerts a paralysing action upon the nerve centres and cardiac ganglia.

Spermin, C_2H_5N.—From semen, testicles, ovaries, breast, thyroid, pancreas, and spleen, normal bone marrow. Poehl states that it has a tonic effect on the nervous system.

Creatinine, $C_4H_7N_3O$.—From urine.

Crusocreatinine, $C_5H_8N_4O$.—From fresh meat.

Xanthocreatinine, $C_5H_{10}N_4O$.—From fresh meat—causes depression, fatigue, somnolence, defæcation, and vomiting.

Betaine, $C_5H_{11}NO_2$.—From urine.

Mytilotoxine, $C_6H_{15}NO_2$.—From poisonous mussels.

The Relation of Leucomaines to Disease.

It will be necessary in considering the relation of leucomaines to disease to give the term a wider significance than that relative to the chemistry of these bodies. Autogenous diseases may be looked upon as having their origin in altered metabolism of the tissue cells, apart from the introduction of foreign cells or poisons. "It is certainly true that if we should drink only chemically pure water, take only that food which is free from all adulteration and infection, and breathe the purest air free from all organic matter living and dead, yet our excretions would contain poisons. It is true that the excretions of all living things, plants, and animals contain substances which are poisonous to the organisms excreting them" (Vaughan). Bouchard estimates that the amount of a certain poison formed in the intestines of a healthy man in twenty-four hours, if absorbed, would prove fatal. Unless free elimination takes place, elevation of temperature may follow.

The products of imperfect digestion, if absorbed, may give rise to serious disturbances. Hildebrandt has shown by his experiments that subcutaneous injection of pepsin into dogs

is followed by elevation of body temperature, which he calls "ferment fever." The fever reaches a maximum within a few hours and may last several days. Rigors are frequent. The animals suffer from trembling in the limbs, uncertainty of gait, vomiting, dyspnœa, and coma followed by death. On *post-mortem* examination there are found degeneration of the heart, muscles, liver, and kidneys, abundant hæmorrhages into the intestine, Peyer's patches, the mesenteric glands, and occasionally into the lungs. The blood is at first lessened in coagulability, afterwards increased, and thrombi formed which have been found in the lungs and kidneys.

Excessive formation of these poisonous substances within the body or insufficient elimination of them produces serious disturbances. Fatigue fever is an example. A considerable rise of temperature may follow excessive and prolonged exercise, the appetite is impaired, and insomnia is present from excitation of the brain and the senses being rendered more acute. There may be rigors simulating malaria. This fatigue fever occurs particularly amongst recruits in armies subjected to prolonged marching. From his observations of this disease in the Italian army Mosso states that it is due to the absorption of poisonous substances into the blood from the tissues, which, if injected into the circulation of healthy animals, produces symptoms of exhaustion. The fever of prostration or exhaustion is similar but less in degree, it is more likely to be produced by prolonged exertion with insufficient food, it may resemble typhus fever, delirium may be present, and loss of muscular control over the bowels; death may result. In non-fatal cases weeks may elapse before recovery takes place.

Rachford has pointed out that an excess of paraxanthine in the blood is followed by migraine, and it may give rise to epileptic seizures, gastric neurosis and asthma; and by injecting paraxanthine into the blood of mice and rats he has produced symptoms of certain forms of epilepsy, and others similar to the nervous symptoms of chronic lead poisoning.

CHAPTER VI.

FOOD POISONING (BROMATOTOXISMUS).

Instances have occurred from time to time of serious illness attacking individuals either separately or collectively shortly after the ingestion of food. The food may be rendered poisonous in the following ways :—

1. A poisonous substance may have been added to it, intentionally or accidentally.

2. Grain may become infected with poisonous fungi, *e.g.* ergot.

3. Plants or animals may feed upon materials harmless to them, but which render them poisonous to man—birds that have fed on mountain laurel are said to have proved poisonous to man.

4. During periods of physiological activity of certain of their glands, the flesh of some animals becomes poisonous to man; some fish, for example, are poisonous during the spawning season.

5. Food may carry infection by contamination with germs, *e.g.* typhoid bacilli in milk.

6. The animal may suffer from a specific disease, and it may be transmitted to man, *e.g.* tuberculosis.

7. Foods may be contaminated with bacteria which produce poisons either before or after the food has been eaten.

8. The food may be infected with parasites or their ova, and which develop in the individual who partakes of it, *e.g.* trichiniasis.

In cases in which the poison has been added or preformed the symptoms of poisoning come on almost immediately or within a short space of time; there may, however, in the latter be a delay in the appearance of the symptoms in instances where the bacterial poison is formed subsequent to the

ingestion of the food. This delay is bordering on the nature of a true infection. In those cases when the bacteria have been present in the animal before, or develop in it subsequent to its death, and which develop in the person who eats it as food, symptoms may not come on for some time; the condition is a true infection, and there may be an incubation period over six or seven days.

Meat Poisoning (Kreotoxismus).

Apart from those cases of poisoning following the ingestion of food to which poison has been added, or from meat affected by parasitic disease, there have occurred outbreaks of serious illness following the partaking of meat. Vaughan, in the *Twentieth Century Practice of Medicine*, vol. xiii. p. 20, holds that "there can scarcely be any difference of opinion on the following points: (1) With fresh food to act upon and with normal gastric juice to act, the process of peptic digestion proceeds without the formation of any harmful substance. (2) with putrid food, containing poisons to start with, the most active digestion does not guarantee the destruction of those poisons. (3) With even the best of food, peptic digestion may proceed so slowly and imperfectly that during the process poisons may be formed by bacterial agencies." During the process of decomposition of meat and other albuminous foods by bacterial agency, certain poisonous substances are formed prior to the production of the ptomaines or bacterial alkaloids. These are known as toxalbumoses and enzymes; they are unstable bodies, they cannot be obtained in a crystalline form, and their composition is not fully understood. They give certain reactions with a few group-reagents, but they are recognised only by their effects upon living animals. As decomposition advances the more stable alkaloids are formed, but those which are poisonous, like the toxalbumoses, are readily converted by further processes of putrefaction or by chemical means into innocuous bodies. Toxines is the general term used in toxicology for these poisonous substances formed from animal tissues.

It is not necessary that complete putrefaction should have taken place for meat to prove poisonous. In fact many of the severest cases are those in which it has not fully putrefied. The most poisonous toxines are present during the early stages

of decomposition, and the changes are not recognisable by the senses—smell or taste—which would ensure the rejection of the meat as food.

The poisonous effects are rarely due to the ingestion of bacterial products alone ; those cases in which no bacteriological investigation of the food has been made cannot be taken into consideration. The toxalbumoses are destroyed by a few minutes' exposure to a temperature at boiling-point, 212° F. (Durham, *B. M. J.* 1898, vol. ii. p. 797).

In reference to the toxic action of the alkaloids, these have been noted only from the results following subcutaneous injection ; their effects when taken per orem have not been established by experiment. In all instances where the necessary bacteriological investigation has been properly carried out a true infection has been proved to have taken place.

In cases of meat poisoning the principal bacteria concerned are not the ordinary putrefactive organisms. The Bacillus enteritidis of Gärtner, which has been found associated with twelve epidemics, and the Bacillus botulinus of Ermenghen are the most important causative agents.

The Bacillus enteritidis is killed by proper cooking. It is destroyed in one minute at a temperature of 180° F. At 41° F. it will not grow, but, in meat kept at 68° F. for seventy-two hours, it flourishes abundantly. Freezing will not kill it. In meat which has been infected with the bacilli *post mortem* they do not penetrate the meat more than 1 cm. in ten days. Roasting or boiling will sterilise it. In those instances in which poisoning has taken place after cooking, the bacilli have either been present in the meat beforehand, and the temperature has not been sufficiently high or the cooking sufficiently prolonged, to ensure their destruction in the deepest portions ; or the meat after cooking has become contaminated, and been insufficiently warmed up again after keeping it for a day or so. Exposure to sewer gas will not affect meat and contaminate it with the Bacillus enteritidis. The chief symptoms due to the Bacillus enteritidis are vomiting and diarrhœa, herpes labialis, rashes on the skin, followed by desquamation in about fourteen days, jaundice, and great thirst. The onset is sudden, with nausea, headache, pains in the back and limbs, rigors, fever lasting a few days, general weakness, and, in cases which recover, convalescence extending over a period of from three to six weeks.

The symptoms of botulismus, due to the Bacillus botulinus of Ermenghen, and associated with sausage poisoning, are, as a rule, dryness of the mouth, constriction of the fauces, nausea, vomiting, purgation, vertigo, dilatation of the pupils, with dimness of vision and diplopia, and a sense of suffocation. Marked muscular weakness and nervous prostration are prominent symptoms. In fatal cases there is weakness of the pulse and cyanosis, with coldness of the surface and perspiration. The temperature is raised at first and may reach 103° F., but ultimately falls below normal. Delirium comes on late, followed by coma and death.

In dangerous cases obstinate constipation may follow after a few hours of watery stools.

On *post-mortem* examination of the bodies in fatal cases the following appearances have been noted: a white, dried, parchment condition of the mouth, fauces, throat, and gullet; hyperæmia of the mucous membrane of the stomach and intestines with submucous extravasations of blood. The abdominal and thoracic viscera have been found engorged with blood, with enlargement of the spleen; the former are due to failure of the heart, and cannot be regarded as characteristic of sausage poisoning. Some stress has been laid on the observation that putrefaction is unusually delayed, but Müller has shown that no reliance can be placed upon it; he says that in forty-eight autopsies it has been noted that in eleven of them putrefaction had developed rapidly.

The symptoms of meat poisoning are grouped by Dixon Mann into two divisions: (1) those due to a true infection, (2) those due to simple poisoning.

In (1) the symptoms are those of an infectious disease—they include headache, anorexia, rigors, constipation followed by diarrhœa, pains in the back and limbs, photophobia, delirium, skin eruptions, meteorism and enlargement of the spleen. The *post-mortem appearances* greatly resemble those of enterica,—infiltration, ulceration, and sloughing of Peyer's patches; hæmorrhage into the bowels, enlargement of the spleen, with possibly some pus depôts.

In (2) the symptoms are those of acute gastro-enteritis,—violent vomiting, purging, prostration, cramps in the legs, and collapse; the temperature is generally subnormal, but may be elevated. The *post-mortem appearances* are those produced by

gastro-enteritis, with hæmorrhages into the intestinal mucous membrane; the spleen is frequently enlarged, and Peyer's patches may be infiltrated.

Meat poisoning has usually been most frequently associated with the ingestion of pork, veal, beef, meat pies, potted meat, tinned meat, sausages, and brawn. The more finely divided the meat, the more easily and completely it may become infected and poisonous. Cases of poisoning from the ingestion of canned meats are not uncommon. In some instances they may be due to metallic poisoning, in the great majority they are due to putrefactive changes having taken place in the meat. Ungefug reports a case confirmed by the celebrated chemist Heinrich Rose, in which sulphate of zinc had been used as a preservative instead of saltpetre. In some the canning may have been imperfect, and putrefaction taken place before reaching the consumer; in others decomposition may have begun after opening the can. The meat may have been taken from diseased animals, or decomposed prior to canning.

Poisoning by tinned provisions with the metal used for tinning is more likely to occur with fruits than meat. The malic acid of the juice probably dissolves the solder and forms a malate of tin. Cherries, apples, pineapples, and tomatoes are the most likely to do this.

In 1890 Luff investigated four cases of tin poisoning due to the consumption of tinned cherries. Some of the material left was analysed, and the juice contained malate of tin in solution equivalent to two grains of the higher oxide of tin per fluid ounce. It was estimated that the symptoms were produced by doses of two to four grains of malate of tin. Two of the patients nearly died from the diarrhœa and collapse.

Sulphate of copper is used to give a full green colour to peas, olives, and pickles, or it may contaminate preserved fruits if they be left in copper vessels. The copper combines with the phyllocyanic acid of the chlorophyll, and although insoluble in the surrounding liquor, is set free and absorbed by the process of digestion.

Fish Poisoning (Ichthyotoxismus).

Fish may cause poisoning in two ways: in one the poison is a physiological product of certain glands of the animal, and

is quite independent of bacteria; the other is due to the poisonous products of bacterial growth. The fish that are inherently poisonous as a rule occupy tropical waters: several of them exist in Japanese waters. Mackerel, carp, barbel, and herrings may become poisonous at times; some of these, especially mackerel, may rapidly become unfit for food after they are dead. Caviare and the roe of herrings have caused poisoning. Shell-fish, especially mussels, also may prove poisonous.

The symptoms of fish and shell-fish poisoning are variable. In some cases disturbance of the nervous system predominates, with delirum, convulsions, and paralysis. There may be dryness and constriction of the throat, dyspnœa, disturbed vision, vertigo, jerky speech or aphonia, rapid pulse, loss of co-ordination, numbness, formication, coldness of the limbs, dilated pupils, paralysis and collapse, followed by death in a few hours. Other cases exhibit symptoms of severe gastro-intestinal irritation, with nausea, vomiting, pain, tenesmus, mucous and bloody stools; in the most dangerous cases the bowels are constipated. Cases exhibiting the nervous type of symptoms resemble poisoning by atropine, and an alkaloid—ptomatropine—is regarded as the cause. It has never been obtained in the pure state, and nothing is known of its composition. It must not be mistaken, in toxicological examination, for atropine; its presence can only be recognised by its action on the pupil.

Many cases of fish poisoning are accompanied by erythema, urticaria, and severe itching of the skin. In probably all cases there is an elevation of the body temperature.

Tinned fish has caused poisoning on many occasions. In one case of tinned salmon poisoning, which proved fatal, parts of the stomach and intestines were almost gangrenous from the intensity of the inflammation.

Stevenson (*Brit. Med. Journ.* 1892) records a case of sardine poisoning which proved fatal, and in which the tissues *post mortem* were found to be emphysematous. He extracted an alkaloid from some of the sardines, and the stomach contents; it was highly toxic and proved fatal to rats.

It is most probable in poisoning by tinned fish that the contents of the tins have become contaminated with bacteria before being sealed up.

Shell-fish may become contaminated with bacteria and cause true infections in people who eat them. Typhoid fever has

been carried in this way by oysters, and probably cockles. The fish may develop toxines and prove poisonous, and as an example of this mussels produce a powerful toxine—*mytilotoxine*—while they are alive, which gives rise to a serious illness termed mytilotoxismus. There are three quite different classes of symptoms induced by poisonous mussels. In one the symptoms are principally those of acute gastro-enteritis; in another skin eruptions are the principal feature; and the third is known as mytilotoxismus paralyticus, in which there is great disturbance of the cerebro-spinal nervous system, with paralysis. The two former groups of symptoms are due to putrefactive processes in the mussels, but the third or paralytic group is due to the alkaloid *mytilotoxine*, which is not a product of putrefaction, as it is not found in mussels that have been allowed to decay.

There is nothing to evidence the idea that mussels absorb metallic poisons—*e.g.* copper—from the bottoms of vessels.

Poisoning by Milk and Milk Products.

The term milk poisoning or galactotoxismus is used here to indicate the results following the drinking of milk infected with saprophytic toxicogenic bacteria, and which are mainly responsible for the high mortality from "summer diarrhœas" of artificially-fed infants. One of the products of these bacterial infections of milk is the alkaloid *tyrotoxicon.* It has been isolated by Vaughan from cheese, and has also been found in ice-cream, frozen custards, and cream puffs. Vaughan, however, asserts that it is not the one most frequently present, nor is it the most actively poisonous. There are others which he considers are poisonous albumins (Vaughan, *Twentieth Cent. Pract. Med.* vol. xiii.).

The symptoms of poisoning by tyrotoxicon are mainly those of acute gastro-enteritis, and comprise constriction of the fauces, nausea and vomiting, sharp griping intestinal pains, headache, thoracic oppression, chilliness, dizziness, and purging. In severe forms exhaustion, subnormal temperature, coma, collapse and death may follow.

TRICHINIASIS.

This disease is due to the introduction of the *Trichina spiralis* into the human body. The encysted worm is found embedded in the fibres of all the striped muscles of the trunk

and limbs, and even in the heart, where it appears in the form of white ovoid bodies or capsules, the capsules being sometimes calcareous. The worm passes the greater part of its existence in the chrysalis state in the muscular system of one animal, and only reaches its mature condition in the stomach of another. Virchow and Zenker assert that the trichina not only frequently presents itself in the human organism, but that this organism is most favourable for its full development. Once in the stomach, the period of incubation is about three to eight days, and then propagation rapidly begins, and continues, so that Dr. Kellen estimates that in about seven days after the ingestion of half a pound of meat the stomach and intestines may contain thirty millions of the worms. The worms when introduced into the stomach leave their capsules, become free, produce young, and these leave the stomach through its coats for the muscles, where they become encysted. The trichina is most frequently found in pork, seldom in sheep, horses, or oxen—the last being the freest.

Symptoms.—Intestinal irritation, loss of appetite, sickness, malaise, general weakness of the limbs, and diarrhœa. The eyelids swell as well as the joints, the skin is bathed in cold, clammy sweat, and a low form of fever sets in. Death may be due to peritonitis, paralysis of the muscles—the result of their destruction,—or to irritative fever. During the perforation of the coats of the stomach and bowels by the worms, the mucous membrane becomes inflamed, pus is formed on the surface, and the stools become bloody.

TOXICOHÆMIC, SNAKE POISONS, ETC.

Under this head may be classed all those effects produced by the sting or bite of various insects and reptiles, and also by the bite of the mad dog and wolf.

No medico-legal question is likely to be raised on this subject, at least in this country, where, with the exception of the common viper or adder, all our reptiles are harmless enough.

CHAPTER VII.

THE VEGETABLE ALKALOIDS.

Vegetable alkaloids may be classified in three groups: (1) derivatives of pyridine, *e.g.* atropine, conine; (2) derivatives of quinoline, *e.g.* cinchonine, narcotine; (3) substituted amines and amides. The majority of the vegetable alkaloids belong to the first two groups. They are for the most part solid, crystalline, and colourless; a few, such as conine, nicotine, and pilocarpin, are liquid. They combine with acids to form salts, and the salts are more soluble in water than the free alkaloid. Alkaloids possess certain properties in common, amongst which is that of being precipitated from their solutions by certain reagents, which are called alkaloidal grouping reagents. Some are precipitated by all the group reagents, others only by a few.

Alkaloidal Group Reagents.

1. *Iodine dissolved in solution of Potassium Iodide—Wagner's reagent.*—Gives a redddish-brown precipitate with most alkaloids.

2. *Phosphomolybdic Acid—Sonnenschein's reagent.*—Made by dissolving phosphomolybdate of soda in water containing one-tenth its volume of strong nitric acid. It gives a yellow precipitate with most of the alkaloids; it also precipitates ammonium salts and ammonia derivatives, also salts of lead, silver, and mercury unless there be sufficient acid to keep them in solution.

3. *Potassio-mercuric Iodide—Mayer's reagent.*—Made by adding a solution of potassium iodide to one of mercuric chloride until the red precipitate first formed be just dissolved. This solution precipitates most of the alkaloids. The solution to be tested must not contain acetic acid.

4. *Phosphotungstic Acid—Scheibler's reagent.*—This acts in a manner very similar to phosphomolybdic acid.

Methods for detecting Vegetable Alkaloids.

There are several methods recommended for the isolation and detection of the vegetable alkaloids, and their separation from the contents of the stomach or from the membranes and tissues of the body. The process, however, most generally pursued is that of Stass, which may be briefly described as follows:—

(*a*) The substance to be examined is mixed with twice its weight of absolute alcohol, to which from ten to thirty grains of tartaric or oxalic acid—preferably the former—have been added, and the mixture subjected to gentle heat in a flask, 70° to 75° C., or 158° to 167° F.

(*b*) If the membranes or organs have to be examined, they are finely divided, treated with absolute alcohol, squeezed, and again treated with fresh alcohol as in (*a*).

In either case, the mixture, when quite cold, is filtered, and the alcoholic solution is concentrated by evaporation, either *in vacuo* or in a current of air not exceeding 95° F. or 35° C.

The liquid residue is now passed through a moistened filter, which separates the fat and other insoluble matters. The filtrate is evaporated to dryness over sulphuric acid or *in vacuo*, and the acid residue of this evaporation dissolved in the smallest possible quantity of distilled water. The acid liquid is then *gradually* neutralised with the bicarbonate of potash or soda until effervescence ceases, and afterwards shaken in a flask with four or five times its bulk of pure ether, and allowed to settle. When the ether has become quite clear, a small portion of it is decanted into a small glass capsule, and allowed to spontaneously evaporate in a dry place. If during evaporation streaks of liquid appear on the side of the capsule, running together at the bottom, a liquid volatile alkaloid is probably present. If none of these manifestations occur, the alkaloid is in all probability solid and non-volatile.

If morphine has to be sought for, the liquid should be shaken with ether immediately after being neutralised with carbonate of sodium, and the ether poured off as quickly as possible; for if the alkaloid have time to separate in the crystalline form, scarcely any of it is dissolved by the ether (Otto).

The method of Stass is based upon the fact that the salts of the alkaloids, as a class, are soluble in water and alcohol, but

are insoluble in ether; and that these salts when in solution are readily decomposed by the mineral alkalies with the elimination of the alkaloids, which, in their free and uncombined state, are more or less readily soluble in ether.

The Alkaloid is Volatile.	*The Alkaloid is Non-Volatile.*
To the original mixture in a flask add a moderate quantity of a strong solution of caustic potash or soda, mixed with ether; agitate, and allow the mixture to settle. Pour off the ethereal solution, and re-shake residue with a fresh quantity of ether; decant, and mix both solutions. The ethereal solution is now shaken with a mixture of four parts of water and one of sulphuric acid, which withdraws the alkaloid from its solution, leaving any fatty matter dissolved in the ether. The acid solution is now mixed with strong potash or soda solution in excess,[1] agitated with ether, the ether poured off, and then evaporated at as low a temperature as possible,[2] leaving the pure alkaloid with all its characteristic chemical and physical properties.	To the original mixture in a flask add strong caustic potash or soda solution, and agitate with successive portions of pure ether, allowing it to completely settle each time. The ethereal solutions, being mixed, are evaporated, leaving the alkaloid in an impure state. To purify it, the solid residue left on evaporation is treated with a small quantity of dilute suphuric acid, which dissolves the alkaloid, leaving any fatty impurities behind. The acid liquid is evaporated to three-quarters of its bulk over strong sulphuric acid, and then a saturated solution of carbonate of potash or soda added. The absolute alcohol will then dissolve out the pure alkaloid, giving it, on evaporation, in the crystalline form, and in a state to shows its characteristic reactions.

Otto's Method.—Otto's modification of Stass' process is simpler, and at the same time equally accurate. Instead of numerous treatments and evaporations which have to be gone through in the original process, Otto converts the alkaloid into a salt, such as the sulphate, by the addition of acid, and after solution in a small quantity of water, agitates with successive quantities of ether, which remove all foreign fatty matters, leaving the solution of the alkaloid comparatively pure, and from which the alkaloid may be obtained in a state of great purity, by first rendering the solution alkaline and then using ether to dissolve the alkaloid.

R. Wagner's Method.—The presence of alkaloids in organic

[1] The sulphates of alkaloids are insoluble in ether; hence they must be decomposed by an alkali.

[2] The temperature should be low, or the greater part of the conine will be evaporated with the ether.

liquids—strychnia in beer, for example—may, according to R. Wagner (*Zeitschr. Anal. Chem.* vol. iv. p. 387), be detected by mixing the liquid, diluted with two vols. water ($\frac{1}{2}$ to 1 litre), with about 5 c.c. of a solution of iodine in potassium iodide (12·7 grains iodine to the litre) and a few drops of sulphuric acid. The precipitate separated from the supernatant liquid is dissolved in a dilute solution of sodium hyposulphite, and again precipitated by means of the iodine solution. If this new precipitate be now dissolved in aqueous sulphurous acid, the solution will leave, on evaporation, the pure sulphate of the base.

Dragendorff's Method.—This is intended for the purpose of separating alkaloids from each other when more than one are in aqueous solution, by using different solvents in sequence. Some solvents take up certain alkaloids to the exclusion of others. The process consists of extracting the aqueous acid solution of the alkaloids successively with petroleum spirit, benzene, and chloroform, then alkalising it and repeating with the same solvents.

1. From the *acid* solution *benzene* removes caffeine, colchicine, santonin, digitalin, cantharidin. *Chloroform* removes papaverine, colchicine, narceine, picrotoxin.

2. From the *alkaline* solution *petroleum ether* removes strychnine, brucine, aconitine, veratrine, conine, nicotine, lobeline, emetine, and aniline. *Benzene* removes atropine, hyoscyamine, physostigmine, codeine, narcotine, and further quantities of strychnine, brucine, aconitine, veratrine, and emetine. *Chloroform* removes morphine, narceine, papaverine, strychnine, and brucine. *Amylalcohol* removes morphine, solanine, and narceine.

The Stass process cannot be recommended for the detection of opium in organic liquids, for two reasons. Firstly, that it altogether fails to indicate the presence of meconic acid; and, secondly, because morphine is almost insoluble in ether. Dragendorff recommends the use of *benzole* for separating the alkaloids, but in this substance morphia is nearly insoluble. It is, however, applicable to strychnine, aconitine, conine, and atropine; but for the two last, on account of their volatility, ether is preferable.

Stevenson's Modification of the Otto-Stass Process.—The material to be examined, if solid, is finely divided, and

digested for twenty-four hours with twice its weight of rectified spirit at 35° C.; if fluid, with twice its volume. The clear liquid is decanted and the residue again digested with fresh spirit; this is again decanted, and mixed with the first alcoholic solution. The residue is now digested with spirit faintly acidified with acetic acid; this is decanted, and the residue digested with two or three lots of unacidified alcohol. The alcoholic extracts obtained before acidification are mixed together and rapidly raised to 70° C. for a moment or two. They are quickly cooled and filtered, and the filter washed with spirit. The acidified extract and those after it are mixed and treated in the same way. The extracts are then separately evaporated at a temperature not above 35° C. to the consistency of a syrup, the excess of acid being neutralised with soda; these are extracted with absolute alcohol and the extracts evaporated to a syrup as before. The syrupy extracts are now diluted with a small quantity of water, filtered, the filters washed with water, and the filtrates mixed. The liquid will contain the whole of the alkaloids, and will be free from albuminoids, which have been coagulated while the extracts were at 70° C. The liquid containing the alkaloids is extracted several times with washed ether, which removes fatty acids or oils, but does not remove alkaloidal salts. The ether should be washed with water to which a few drops of sulphuric acid has been added, and the water kept: this has to be done because some alkaloidal salts are slightly soluble in ether. The acid liquid and the acidified aqueous washings of the ether are mixed together, rendered alkaline with sodium carbonate, and exhausted firstly with a mixture of one volume of chloroform to three of ether, and lastly three or four times with ether alone.

The alkalisation with sodium carbonate liberates the alkaloids from their salts, and these are soluble in the chloroform-ether and ether. These ethereal extracts are then washed with water acidified with sulphuric acid, and water alone, and the washings mixed. The water acidulated with sulphuric acid converts them into sulphates, which are insoluble in the ether and chloroform, and are removed by the acidified water, while impurities are left behind. The mixed aqueous and acid extracts are again washed with ether, the ether removed, and the liquid re-alkalised with sodium carbonate and then re-extracted with chloroform-ether and ether.

The ethereal solutions are removed and are washed with water slightly alkalised with sodium carbonate. The ethereal solution is filtered through a dry filter, the filtrate evaporated to dryness first at 35° C. then at 100° C., and cooled over sulphuric acid. The residue is weighed and represents the weight of the alkaloids. A test quantity should be evaporated to see if there be any oily odorous residue, *i.e.* a volatile alkaloid, nicotine or conine. If so, the chloroform and ether extracts

Fig. 31.—Photo-micrograph of crystals of hydrochloride of morphine, ×50. (R. J. M. Buchanan.)

should be mixed with a little pure ether and strong hydrochloric acid; the alkaloids are thus changed into non-volatile hydrochlorides, which are left behind after evaporation of the chloroform and ether. Any alkaloid found should be converted into the hydrochloride, dissolved, and tested by special tests. Morphine cannot be extracted except in very minute amounts by this method. To obtain it, the first alkaline solution from which the other alkaloids have been removed should be extracted with acetic ether and ether, in which morphine is soluble.

Taylor's method for the extraction of morphine may be briefly described as follows :—

The liquid—porter, etc.—to be examined is acidified with acetic acid ; or, if a solid organ is to be tested, it must be cut into thin slices and placed in distilled water acidified in a similar way. In either case the liquid is digested for one or two hours at a gentle heat, and filtered. Acetate of lead is now added to the filtrate until no further precipitation occurs ; the liquid is

FIG. 32.—Photo-micrograph of meconic acid crystallised from aqueous solution, ×50. (R. J. M. Buchanan.)

then boiled and filtered. The meconic acid remains on the filter as meconate of lead, while the filtrate contains the morphine as acetate. The liquid is freed from excess of lead by passing through it a current of sulphuretted hydrogen, filtered to remove the precipitated sulphide of lead, and the resulting liquid evaporated to an extract on a water bath, and treated with alcohol. The alcoholic solution on evaporation gives acetate of morphine, which may then be tested.

The meconate of lead which remains on the filter is decomposed by treating it with dilute sulphuric acid, and gently

boiling the mixture. The filtered liquid should be neutralised before the tests for the presence of meconic acid are applied.

FIG. 33.—Photo-micrograph of meconic acid crystallised from an alcoholic solution, ×50. (R. J. M. Buchanan.)

The reactions of both morphine and meconic acid are best seen from the following Table:—

MORPHINE—SOLID.

Treated with strong nitric acid .	Dissolves with effervescence and the production of ruddy fumes, forming a rich orange-coloured solution not changed by the addition of stannous chloride.
Mixed with a little iodic acid and starch paste.	A blue colour, due to the liberation of iodine.
Dissolved in cold strong sulphuric acid, and a drop of strong solution of bichromate of potash added.	Bright-green colour.
Rubbed with sulphomolybdic acid (Frohde's reagent).	A violet colour changing to green, and then sapphire-blue.

Morphine and Meconic Acid in Solution.

	Morphine.	Meconic Acid.
Tested with litmus paper.	Slightly alkaline.	Very distinctly acid.
A little perchloride of iron, rendered as nearly neutral as possible.	An inky-blue colour, destroyed and changed to orange-red by nitric acid.	Deep red colour, not easily destroyed by a solution of corrosive sublimate or dilute mineral acids.

The characteristic tests for morphine are its reactions with nitric acid, iodic acid and starch, and perchloride of iron. The reaction with the perchloride of iron is also characteristic of meconic acid. This last-mentioned test is a very conclusive one for meconic acid, when certain precautions are taken ; for the property of striking a deep red with a persalt of iron is shared equally by sulphocyanides and alkaline acetates. The colour produced by sulphocyanic acid *is instantly bleached* on the addition of *corrosive sublimate.* The question thus lies between acetic and meconic acid. To distinguish the one from the other, the solution to be tested should be boiled for a short time after the addition of a few drops of sulphuric acid. Any acetate present is decomposed, and the acetic acid is expelled by the boiling ; so that if, after allowing the solution to cool, it still gives the red colour with perchloride of iron, the reaction may be taken as conclusive of meconic acid. By these means morphine and meconic acid may be detected in porter and other liquids.

[Table

TABLE SHOWING THE CHARACTERS AND TESTS OF THE FOLLOWING POISONS.

MORPHINE.	STRYCHNINE.	BRUCINE.	NARCOTINE.
1. Crystallises in colourless transparent prisms, belonging to the trimetric system.	1. Crystallises in white four-sided prisms, terminated by four-sided pyramids.	1. Crystallises in oblique rhomboidal prisms, sometimes agglomerated mushroom-like heads.	1. Crystallises in right rhombic prisms, or in needles grouped in bundles.
2. Sulphuric acid and bichromate of potash give a bright-green colouration.	2. Treated with cold sulphuric acid, no reaction ; on the addition of a crystal of potassium bichromate, an intense purple colour is produced, becoming crimson and then light red.	2. Sulphuric acid gives a rich rose-pink tint ; on the addition of potassium bichromate, none of the reactions of strychnine are observed.	2. Sulphuric acid a bright sulphur-yellow colour, potassium bichromate added a green colour as with morphine, but slower in production.
3. Strong colourless nitric acid, added freely to a cold solution, produces a deep orange-red coloration, not changed by stannous chloride.	3. Strong nitric acid usually produces a yellow or yellow-brown colour.	3. Strong nitric acid produces a blood-red colour, changed to purple by stannous chloride.	3. Strong nitric acid forms a colourless fluid, becoming yellow on heating.

CHAPTER VIII.

NARCOTIC POISONS.

Somniferous.

OPIUM.

Opium is the inspissated juice of the *Papaver somniferum*, the garden or opium poppy. The plant is a native of Egypt and Syria, cultivated in England.

Opium is sometimes taken in its crude state as a poison, but more frequently one of its preparations is thus employed—notably the tincture, better known as laudanum.

The poisonous properties of this drug reside in an alkaloid, *morphine*—in combination with an acid, *meconic acid*. The several varieties of opium vary considerably in the quantity of morphine which they contain, the amount varying from 2 to 9 per cent.

Opium, or its alkaloid, morphine, forms an important ingredient in *Dalby's Carminative*, *Winslow's Soothing Syrup*, *Godfrey's Cordial*, *Chlorodyne*, *Nepenthe*, etc.

Of all forms of poisoning, that by opium and its preparations is the most frequent; and it is stated that three-fourths of all the deaths from opium occur among children *under five years of age*.

Symptoms.—The rapidity with which the symptoms of poisoning by opium make their appearance will depend upon the form in which the poison is taken—solution, of course, increasing the activity of the drug. In most cases, an interval of from half an hour to an hour elapses after the poison has been swallowed before any evil effects become apparent. Christison, however, mentions a case in which stupor did not show itself for eighteen hours. During the first stage of poisoning by opium, the patient may become slightly excited; this state is,

however, soon followed by giddiness and drowsiness. The eyes are kept open with difficulty. Stupor and insensibility now supervene, from which he may, in most cases, be temporarily aroused by a loud noise or a smart blow. As the case progresses, coma and stertorous breathing occur, and it becomes almost impossible to rouse him at all. The pulse, at first small, quick, and irregular, becomes slow and full as the coma increases. The breathing, hurried in the early stages, is now slow and stertorous. The pupils are contracted in the early stages, and may be in the later stages dilated; the former condition is most frequently present, together with insensibility to light. The pupils may be contracted in cases of *hæmorrhage into the pons Varolii*, and this disease has been mistaken for opium poisoning. In uræmic coma, coming on in the course of Bright's disease, the pupils may also be contracted; the nature of the case will be explained by the history and presence of dropsy. All the secretions, except that of the skin, are suspended, and the bowels are usually obstinately confined. The breath may be impregnated with the odour of opium. Certain anomalies in the symptoms may occur; thus, there may be vomiting and purging, convulsions (the last most frequent in children), delirium, tetanic spasms, one pupil dilated and the other contracted, paralysis, and anæsthesia. It must be borne in mind that remissions sometimes occur in the symptoms, the patient dying after an attempt at recovery

A question of some importance may arise as to the amount of volition and power of locomotion which may exist for some time after a poisonous dose has been taken. Death may be due to causes other than the effect of poison. It must, at least, be admitted as possible, that a person, after swallowing a quantity of opium sufficient to cause death, may yet be able to walk and move about for one or two hours.

Opium-eating.—If opium be taken for some time in small doses, the system becomes tolerant of it, so that a dose which would be poisonous to most people only produces a slight and pleasurable excitement. De Quincey was in the habit of taking daily nine ounces of laudanum. The habitual opium-eater generally suffers from disorders of the digestive organs, dyspepsia, and its train of unpleasant symptoms; the body becomes thin, the countenance attenuated, the eyes sunken

and glassy, the gait halting, and the body bent. The craving for the drug, which becomes greater and greater, is only temporarily satisfied by larger and larger doses. The opium-eater seldom attains a great age, usually dying before forty. This is perhaps a somewhat exaggerated picture of the ill effects of opium-eating. Christison, after quoting the results of his observations in twenty-five cases of confirmed opium-eaters, concludes as follows: "These facts tend on the whole rather to show that the practice of eating opium is not so injurious, and an opium-eater's life is not uninsurable, as is commonly thought, and that an insured person, who did not make known his habit, could scarcely be considered guilty of concealment to the effect of voiding his insurance. But I am far from thinking (as several represent who have quoted this work) that what has now been stated can with justice be held to establish such important inferences; for there is an obvious reason why, in an inquiry of this kind, those instances chiefly should come under notice where the constitution has escaped injury—cases fatal in early life being more apt to be lost sight of, or more likely to be concealed."

Effects of External Application.—The application of opium to the surface of the body is not usually attended with dangerous symptoms; but, in a few cases, due probably to some idiosyncrasy, alarming effects, or even death, have resulted from the external application of the drug. Orfila has tried to show that opium is readily absorbed by the coats of the rectum, and that it acts more rapidly than when taken into the stomach. This statement does not appear to be correct, for the dose administered by enema is usually twice that given by the mouth.

Post-mortem Appearances.—As might be expected, the appearances found after death are not very characteristic. The vessels of the brain are congested, and serous effusions in the ventricles or between the membranes are not uncommon. Engorgement of the lungs is most frequently present in those cases in which convulsions have occurred. The stomach is in most cases found quite healthy. The bladder may be full of urine, due probably to the person being unable to empty it from loss of consciousness.

Fatal Period.—From three-quarters of an hour and upwards.

Fatal Dose.—Four grains is about the smallest fatal dose of

opium in an adult; but cases of recovery, where an ounce or more of laudanum has been taken, are not very rare. Children are very susceptible to opium. The smallest dose of morphine that has proved fatal to an infant is one-twelfth of a grain of the hydrochloride. Half a grain of the acetate has proved fatal to an adult, one grain of morphine or its salts has proved fatal on several occasions. With prompt treatment recovery has taken place after much larger doses, even as much as seventy-five grains.

Chemical Analysis and Tests.—These have been described on pp. 377 *et seq.*

Treatment.—The stomach pump should be used without delay, and the stomach thoroughly washed out. The washing water should contain about ten to fifteen grains of permanganate of potash to the pint, and the washing repeated at short intervals, as the permanganate destroys the morphine. If the stomach tube be not at hand, the patient should be made to drink the permanganate solution if possible. This treatment should be carried out even when morphine has been administered hypodermically, as it is excreted by the stomach. Emetics should also be given if the patient can swallow; if unable to do so, a hypodermic of $\frac{1}{10}$ grain of apomorphine may be given. The administration of strong coffee or tea, the application of ammonia to the nostrils, flagellation of the soles of the feet, and keeping the patient constantly walking about (a procedure of doubtful value) are among the measures usually adopted by way of treatment. Galvanism and artificial inflation of the lungs have done good service even in the most hopeless cases. The student is referred to some important cases recorded by Dr. Burgess and others in the *Medical Press and Circular*, vol. i. p. 369, for the year 1892. Dr. Burgess strongly recommends prolonged artificial respiration, the interrupted current, and the administration of stimulants, externally, internally, and hypodermically. Dr. Finny is of opinion that, while opium may be useful in cases of atropine poisoning, atropine is of little use in opium poisoning; in this opinion Dr. Burgess concurred. The state of the respiration is a better test than the condition of the pupil when atropine is used as an antidote. If the administration of atropine does not quicken the respiration it should be discontinued, and other methods tried. Vinegar should not be given, as it dissolves the morphine and renders it

more easy of absorption. Death is rare in those cases in which proper remedies have been resorted to before the stage of stupor has commenced.

Synopsis of the Effects of Opium upon the System.

1. *The Mental Faculties.*—The first effect noticed when opium is taken in small doses is a primary exaltation of the mental faculties; the imagination is rendered brilliant, and the passions exalted; after a time drowsiness supervenes, followed by deep sleep. A dose of thirty drops of the tincture caused in one experimenter an exhilaration of the mental faculties, and an aptitude for study; the subsequent drowsiness being removed by a dose of a hundred drops or more, when the greatest mental excitement was the result.

2. *The Respiration.*—The frequency of the respiration is diminished, and the oxidation of the blood impaired.

3. *The Pulse.*—The first effect on the circulatory system is that of a stimulant, and then sedative. By the administration of repeated small doses, the force of the circulation may be maintained for some time.

4. *The Eyes and Countenance.*—The pupils, when the patient is powerfully under the influence of opium, are contracted even to a point. Dilatation, has, however, been noticed in some cases, especially when death approaches. In apoplexy of the pons Varolii, the pupils are contracted. The countenance is placid, pale, and ghastly; the eyes heavy, and the lips livid.

5. *The Cutaneous System.*—The skin, although cold, is not infrequently bathed in profuse perspiration.

6. *The Alimentary Canal.*—Sometimes there is vomiting and even purging; but, as a rule, the secretions along the whole alimentary canal are diminished, and constipation is the result. According to Dr. Walter Smith, of Dublin, morphine is mainly excreted into the stomach and bowels and so cast out in the fæces. Very little goes out in the urine.

7. *The Average Commencement of Symptoms.*—Much depends upon the size and form of the dose. In most cases the first appearance of the symptoms is seldom delayed beyond an hour after the poison is taken.

8. *The Average Period of Death.*—Seven to twelve hours.

Table showing some of the Symptoms and Effects of Opium and Belladonna.

Opium.	Belladonna.
1. Slight excitement, coma, lethargy, and no return of the excitement should the patient recover.	1. Active, busy delirium preceding the coma, followed by delirium, if recovery takes place.
2. Coma is of shorter duration than in poisoning by belladonna.	2. Coma is of longer duration than in poisoning by opium.
3. Pupils contracted.	3. Pupils dilated.
4. Local application to the eye does not affect the pupil.	4. Dropped into the eye, the pupils are dilated.
5. Bowels as a rule confined.	5. Bowels not affected.
6. Acts powerfully on children.	6. Well borne by children.

Table showing the Points of Distinction between Apoplexy and Narcotic Poisoning.

Apoplexy.	Narcotic Poisoning.
1. Apoplexy *may* be preceded by premonitory symptoms, as giddiness, headache, noises in the ears, and partial paralysis.	1. No premonitory symptoms, except by fortuitous combination.
2. Apoplexy chiefly attacks the old, and is very rare in young people.	2. More frequently in the young, especially of the female sex.
3. Most frequently among fat people.	3. In fat or thin people.
4. Symptoms may come on during the meal or *immediately* after.	4. An interval of from ten to thirty minutes always occurs, even in the case of opium, the commonest of narcotic poisons.
5. The symptoms commence abruptly, sometimes with deep stupor.	5. The symptoms advance gradually.
6. Patient is with difficulty, if ever, temporarily aroused. Convulsions common. Face bloated. Pupils *dilated*, or irregular.	6. Patient may be roused from the deepest lethargy if shaken or spoken to in a loud voice. Convulsions rare in opium-poisoning. Face seldom bloated. Pupils *contracted.*
7. Life may be prolonged for a day or more. Apoplexy *may*, however, kill in an hour.	7. Life is seldom prolonged beyond six or eight hours. Shortest time in which opium has caused death, *three* hours.
8. No response when the forehead is smartly tapped with the finger nails, or when water is injected into the ear.	8. Patient may be roused by tapping the forehead, etc.

Table showing the Condition of the Pupils in—

Ordinary sleep . . .	The eyes turned upwards ; pupils contracted.
Chloroform narcosis . .	When the *liquid* is taken, coma ; pupils dilated ; eyes suffused or glistening, and turned upwards. When the *vapour* is inhaled, pupils first contracted ; when coma supervenes, dilated.
Apoplexy	Pupils dilated ; insensible to light. Sometimes unequal. Apoplexy of pons Varolii, pupils contracted.
Alcoholic coma . . .	The pupils dilated or variable, and not affected by a bright light placed before them.
Poisoning by opium . .	Contracted in some cases to a pin's point ; as death approaches, the pupils dilate.
Carbolic acid . . .	Contracted and insensible to light.
Calabar bean . . .	Powerful contraction of the pupils.
Hyoscyamus or atropine .	Dilatation of the pupils.
Strychnine . . .	In some cases the pupils, during the paroxysms, are dilated, and contracted during the intermissions.
Aconite	Sometimes contracted ; but in 17 out of 20 cases recorded by Dr. Tucker, dilatation was present.

CHAPTER IX.

DELIRIANT POISONS.

UNDER this head will be noticed those poisons whose action on the animal economy is characterised by *delirium,* illusion of the senses, and marked *dilatation* of the pupil. In some cases there is considerable irritation of the digestive organs, accompanied with a difficulty to pass water, sometimes ending in complete suppression of urine.

The following are among the most important poisons of this group :—

1. Belladonna.	4. Solanum Dulcamara.
2. Hyoscyamus.	5. Solanum Nigrum.
3. Stramonium.	6. Solanum Tuberosum.

Those of less importance are *Œnanthe crocata* or Dropwort, Camphor, Salicylic Acid, and Yew—the last already described among the Vegetable Irritants.

BELLADONNA.

Symptoms.—Taken internally or applied externally, belladonna, *Atropa Belladonna* (*N. O. Solanaceæ*), or its alkaloid atropine, causes dryness of the mouth and throat, with intense thirst. Nausea and vomiting are present in most cases, accompanied with giddiness, double or indistinct vision, active delirium, convulsions, ending in stupor and coma. In the majority of cases an erythematous rash appears on the skin, with elevation of temperature resembling scarlet fever. A very marked characteristic of poisoning by solanaceous plants is *dilatation of the pupil*, the iris in some cases being reduced to a mere line round the pupil. The symptoms in some cases

which have been recorded are almost identical with those of delirium tremens. In other instances there has been little or no delirium, the patient at once passing into fatal lethargy. Alarming symptoms have followed from drinking a decoction of belladonna leaves, which were mistaken and supplied for those of the ash. Accidental poisoning has also frequently occurred among children from their eating the ripe berries of the belladonna plant. Slight symptoms of poisoning are sometimes met with from the use of belladonna plasters to remove the milk from the breasts of women delivered of still-born children, or in cases where the child has died soon after birth. In these cases the patients complain of intense dryness of the mouth, dimness of vision, and itching of the skin. The removal of the plasters will at once arrest the unpleasant symptoms.

In the *Gazette des Hôpitaux*, July 1859, a case is recorded of poisoning by the outward application of belladonna in the form of the following liniment:—Camphorated oil of henbane, ten ounces; extract of belladonna, four scruples. The patient was seriously ill for some days, but ultimately recovered.

Poisoning has also resulted from the use of a solution of atropine (four grains to one ounce) dropped into the eye in the treatment of iritis. (See *British Medical Journal*, 1876, vol. i.)

Post-mortem Appearances.—Congestion of the vessels of the brain, sometimes with fluid blood, at other times with thick black blood. The stomach may or may not be congested; but in cases where the ripe berries have been taken, the mucous lining may be seen deeply dyed by the juice of the berries. The pupils are usually found dilated.

Fatal Dose.—One teaspoonful of belladonna liniment and one drachm of tincture have proved fatal. Recovery has taken place after half an ounce of liniment and extract. Children are less affected than adults. Of atropine half a grain has proved fatal. Recovery has taken place after five grains of the sulphate.

Fatal Period.—Twelve hours to several days.

Chemical Analysis.—From organic mixtures the alkaloid may be obtained by Stass' process, and treated according to Vitali with a little fuming nitric acid, and then dried in a water bath: when cold, it must be moistened with a drop of potassa dissolved in absolute alcohol. A violet colour changing to red

is produced, the violet being characteristic, as strychnia when treated as above gives a red colour. The physiological action on the pupil must also be noted. When the berries are taken, the mucous membrane of the stomach may be found dyed of a purple colour, turned green by alkalies and red by acids. Fragments of the berries may also be found in the stomach.

To a small quantity of solid atropine add a drop or two of strong sulphuric acid, then a crystal of sodium nitrite; a yellow colour is produced, which alcoholic solution of potash changes to reddish-violet and then pale rose.

Free atropine gives a red colour with phenolpthalein; the colour is discharged with alcohol, but reappears on evaporating it.

Gerrard's Test.—Mercuric chloride dissolved in alcohol gives a red colour.

Blyth's Test.—To the solid alkaloid add strong solution of baryta, evaporate to dryness, and heat the residue, when the smell of hawthorn blossom is given off.

Wormley's Test.—An alcoholic solution of bromine gives a crystalline yellow precipitate.

Treatment.—Wash out the stomach and give hypodermic injections of one-third of a grain of pilocarpine, which is the best antidote. Emetics and purgatives, castor oil and animal charcoal may be administered. The symptoms as they present themselves must be treated on general principles.

N.B.—Belladonna has been stated to act in antagonism to opium, and its administration recommended in poisoning by that drug.

HYOSCYAMUS.

Hyoscyamus, *Hyoscyamus niger*, or henbane (*N. O. Solanaceæ*), taken in large doses, produces symptoms not unlike those due to belladonna. There is the same affection of sight—double vision; the same dilatation of the pupils, delirium, confusion of thought, insensibility, and coma. A form of mania, with wild hallucinations, has sometimes been observed to follow the administration of this drug.

The peculiar property of henbane is marked by its tendency to produce a general paralysis of the nervous system. The root has been eaten by mistake for parsnips, when all the

foregoing symptoms were present. The seeds are more poisonous than the roots, the leaves being the least poisonous part of the plant.

Post-mortem Appearances.—The morbid appearances are not unlike those which result from poisoning with belladonna.

Fatal Dose.—Nothing certain can be stated as to the amount required to cause death. Alarming symptoms are said to have followed the administration of ten minims of the tincture, repeated every six hours. Twenty of the *seeds* have caused active delirium. Idiosyncrasy may have something to do with this result. Half a drachm of the tincture is often given to an adult, and repeated every four hours, without any unpleasant result.

Treatment.—As for belladonna, emetics and purgatives, to expel the poison from the system.

STRAMONIUM.

The Thorn Apple, *Datura Stramonium* (*N. O. Solanaceæ*), possesses powerful poisonous properties. These are marked by the production of giddiness, impairment of vision, and syncope. Furious delirium is not infrequent; and in one case where this state was present there was loss of speech. The face is usually flushed, the eyes glistening and restless, and the pupils dilated; in short, the countenance is that of one intoxicated. Taken together, the symptoms are not unlike those produced by belladonna.

Poisoning by stramonium seeds is a favourite mode of procedure among the Hindoos; but as the poison is most frequently given to facilitate robbery, death seldom results from its use. In India, the seeds are mixed with the boiled rice so commonly eaten there, and as they closely resemble the seeds of the common capsicum, the dangerous nature of the mixture is not readily detected. The seeds of the datura can be distinguished by the taste, which is slightly bitter, whereas that of the capsicum is hot and pungent. The outward application of the leaves may give rise to all the appearances of poisoning.

The active principle of stramonium is the alkaloid *Daturine*, which crystallises in colourless quadrangular prisms, with a bitter acrid taste. It resembles atropine and hyoscyamine in chemical properties.

Post-mortem Appearances.—Congestion of the vessels of the brain and its membranes, with some slight gastric irritation.

Treatment.—As for belladonna, emetics and purgatives, to get rid of the portions of the plant swallowed.

Some other solanaceous plants—*Solanum Dulcamara*, Bittersweet or Woody Nightshade, *Solanum nigrum*, or Garden Nightshade, and the *Solanum tuberosum*, or Potato—possess poisonous properties. They, like the other members of the order to which they belong, give rise to symptoms characterised by giddiness, dimness of sight, trembling of the limbs, and delirium. The water in which the potato has been boiled is sometimes used by the vulgar as an application to favus of the scalp.

The active principle of these plants resides in an alkaloid, *Solanine*, which is not a very powerful poison. A rabbit was killed in a few hours by two grains of the sulphate of solanine.

ŒNANTHE CROCATA.

Hemlock, Drop-wort, or Dead-tongue is a poisonous indigenous, umbelliferous plant.

Accidental poisoning by this plant has occurred, the root having been mistaken for parsnip. The symptoms in one of the cases which have been recorded were those of *delirium tremens;* in another, which terminated fatally, vomiting of blood was followed by convulsions. First contraction and then dilatation of the pupil, spasmodic respiration, and an almost imperceptible pulse were the effects noticed. Death may take place in a few hours.

Post-mortem Appearances.—Congestion of the vessels of the brain, and gastric irritation. The face has sometimes a bloated expression, and blood may escape from the ears and mouth.

Treatment.—Purgatives and emetics, to evacuate the stomach, and thus get rid of the poison.

CAMPHOR.

Camphor is a concrete vegetable oil obtained from *Camphora officinarum* (*N. O. Lauraceæ*). Its employment for the purpose of homicide is rare, but several cases of accidental poisoning from the use of the homœopathic solution have been recorded (*British Medical Journal*, 1873, vol. ii. p. 617).

The symptoms are—languor, giddiness, delirium, foaming at the mouth, vomiting of blood-tinged fluid, convulsions, gastric irritation, and great abdominal pain. In one case—that of a young lady aged twenty, who took twenty-five drops of "Epps' Concentrated Solution of Camphor" for a sore throat—all the above-mentioned symptoms were present; she was also unconscious for several hours, and partially paralysed for several days—perfect recovery from the nervous symptoms not taking place for more than six months.

The homœopathic solution (Rubini's) is stronger than that of the British Pharmacopœia in the proportion of 7·2 to 1. For its detection in organic fluids, it may be removed by chloroform; and from fixed oils, by distillation. Water precipitates it from its alcoholic solution.

Post-mortem Appearances.—Those produced by irritants.

Treatment.—Purgation and emetics, to empty the stomach.

SALICYLIC ACID.

This substance, prepared by acting on a mixture of carbolic acid and sodium with carbonic acid at a moderate heat, is used largely for acute rheumatism. In some cases premonitory symptoms of poisoning have demanded a cessation in the administration of the drug. The most usual of these were noises in the ears, difficulty of hearing, amblyopia, delirium, and profuse perspiration. There may be hæmorrhages from the mucous membranes, and into the retina. When the drug was discontinued the symptoms passed off. The symptoms are held by some observers to be due to the artificial and not the natural acid.

CHAPTER X.

INEBRIANT POISONS.

The poisons grouped under this head are characterised by causing delirium, followed by narcotism. Recovery is not infrequently slow, the system suffering more or less severely from the effects of the poison.

In the case of alcohol, loss of appetite, accompanied with considerable gastric irritation, are among the after-effects of the poison.

The chief of this group are—Alcohol, Cocculus Indicus, Poisonous Fungi, Nitro-Benzene.

Others of less importance will be briefly considered.

ALCOHOL.

It will be necessary to consider poisoning by this substance under two forms—acute and chronic. So many anomalies present themselves that it is difficult to give a clear outline of the symptoms.

Acute.—In most cases the symptoms come on within a few minutes after the poison is swallowed. Giddiness, confusion of ideas, and a difficulty in walking straight are among the first effects produced, these being followed by stupor and coma. Nausea and vomiting are the early signs of recovery. In some cases there may be *no* premonitory symptoms, sudden and complete stupor supervening some time after a large dose of alcohol has been taken.

The patient not infrequently recovers from the first symptoms. A relapse takes place; he becomes insensible, and dies convulsed. The countenance wears a vacant expression; the face flushed and bloated, the lips livid, and the pupils dilated and insensible to light. The pupils may be contracted,

but dilate on irritating the skin by a pin-prick or pinch. The sensibility of the pupil to the action of light should be regarded as a favourable symptom. The rapidity with which alcohol acts is not so great as to prevent the individual from walking some distance and performing certain acts of volition. The rapidity with which the symptoms show themselves will depend upon the previous habits of the individual, and the strength and quantity of the alcohol taken. Alcohol, when diluted, induces a preliminary stage of excitement, followed by stupor; but when concentrated, stupor may come on almost immediately after the spirit is swallowed.

The vapour of alcohol may act as a poison, giving rise to the symptoms above mentioned.

Congestion of the lungs or brain, or both together, is in most cases the cause of death in acute poisoning by alcohol.

Chronic.—The habitual dram-drinker suffers from many diseases. The appetite becomes impaired; there is considerable irritation of the stomach and bowels, marked by vomiting and purging. Then follows a long list of organic diseases. The structure of the liver becomes changed; it may increase in size, become lighter in colour, and is then known as "hobnailed" or *dram-drinker's liver.* Jaundice and dropsy may be present as the result of this altered condition of the gland. The kidneys also suffer from granular degeneration. Then follow a long series of nervous complaints: congestion of the brain, paralysis, *delirium tremens*, and insanity. Sudden death by coma not infrequently ends the career of the drunkard.

Delirium tremens is one of the most common results of the habit of drinking; and this affection, it is stated, may be induced by the sudden discontinuance of alcohol in those who are habitually given to its use.

Post-mortem Appearances.—The stomach may present the usual signs of inflammation, due to the irritant action of alcohol. The colour of the mucous membrane of the stomach may be bright red, dark red, brown, or quite pale. The brain and its membranes are sometimes congested, and the intra-cranial vessels gorged with blood. The odour of alcohol may be present in the contents of the stomach; and alcohol may, in some cases, be detected in the lungs, brain, and other organs of the body. The lungs are not infrequently found congested, and the right cavities of the heart full of dark-coloured blood.

Casper examined a case in which the cavities of the heart were empty. The blood is remarkably fluid, and of a dark colour. "Lymphatic exudation between the cerebral meninges, so that the pia mater upon the cerebral hemispheres is seen here and there whitish as if varnished, is not a result of death from drinking, but is the result of the chronic irritation of the brain by habitual drunkenness, and is therefore a very common appearance in the bodies of all drunkards, from whatever cause they have died." One other condition occurring in those dying from the effects of alcohol, is the remarkable long-continued presence of the *rigor mortis*, and perfect freedom from putrefaction, even up to the ninth day, in an atmosphere by no means unfavourable to early decomposition. A condition of the skin known as *cutis anserina*, or "goose skin," was present in some of the cases examined by Casper.

Absorption and Elimination.—From experiments on animals, it has been shown that alcohol is rapidly absorbed, and then eliminated from the system, and that all traces of alcohol may disappear in a few hours, and yet death be the result of its action. Alcohol is supposed to be decomposed in the body, but the exact changes it undergoes do not appear to be very clearly made out.

Fatal Period.—Death has occurred in a few minutes after a large dose of alcohol had been swallowed. The average fatal period is about twenty-four hours. Death may also be an indirect result of the action of alcohol on the system.

Fatal Dose.—Uncertain. The age and habits of the individual must be considered. Between three and four ounces proved fatal to a boy seven years of age.

[TABLE

Table showing the Points of Distinction between Concussion of the Brain, Alcoholic Poisoning, and Poisoning by Opium.

Concussion of the Brain.	Alcoholic Poisoning.	Poisoning by Opium.
1. Marks of violence on the head.	1. The absence of marks of violence, unless the person has fallen on the ground. The history of the case will help in forming an opinion.	1. Same as under alcohol.
2. Stupor comes on suddenly.	2. Excitement previous to the stupor, which comes on suddenly.	2. The symptoms slow in appearing; drowsiness, stupor, lethargy. Muscles relaxed, and locomotion impossible. The patient may be roused by a sharp question.
3. Face pale and cold; the pupils sluggish and insensible to light, sometimes dilated.	3. Face flushed; and pupils generally dilated.	3. The face pale, pupils contracted.
4. Remissions are rare, the patient recovering slowly, and with some confusion of ideas.	4. Partial recovery may take place, followed by death after the lapse of some hours.	4. Remissions are, as a rule, rare in this form of poisoning.
5. Absence of the odour of alcohol in breath; if present, it is probably due to the treatment of bystanders.	5. Presence of the odour of alcohol in the breath.	5. Odour of opium in the breadth.

Chemical Analysis.—Tests for Alcohol :—

1. Characteristic smell.
2. It dissolves camphor.
3. Treated with dilute sulphuric acid and a strong solution of bichromate of potash, the green oxide of chromium is set free, and the vapour of *aldehyde* may be detected by the smell.
4. Burnt under the mouth of a test-tube, moistened with solution of baryta or lime-water, a deposit is formed in the tube of carbonate of baryta or lime.

5. If a few drops of a solution of iodine in iodide of potassium be added to alcohol, and then sufficient caustic potash be added to decolourise it, a crystalline precipitate of iodoform with its characteristic odour will be formed.
6. If copper turnings be added to a solution containing alcohol, then some strong nitric and sulphuric acid, and the mixture warmed, the odour of sweet spirit of nitre will be given off.
7. On warming with sodium acetate and sulphuric acid the odour of acetic ether is evolved.

Alcohol in the Contents of the Stomach or in the Tissues.—The contents of the stomach, or the tissues bruised and macerated in distilled water, should be carefully distilled in a water bath. It will be necessary to neutralise the liquid prior to distillation. The distillate should be mixed with chloride of calcium or anhydrous sulphate of copper, and re-distilled. The liquid thus obtained is shaken with dry carbonate of potash, and allowed to settle. The alcohol rises to the top of the mixture, whence it may be removed by the aid of a pipette, and tested as before mentioned.

Treatment.—Immediate use of the stomach-pump and emetics; to empty the stomach a hypodermic injection of apomorphine may be given. Affusion of cold water to the head, or the injection of cold water into the ears, may be tried. The administration of ammonia, and the employment of galvanism, have been of service in some cases.

COCAINE.

Cocaine is an alkaloid obtained from the *Erythroxylon Coca.* It produces a paralysing effect upon the endings of sensory nerves, and is used as a local anæsthetic. When absorbed into the blood it paralyses the vagus and causes increased rapidity of the pulse. Applied to the eye it causes dilatation of the pupil. It first has a stimulating action on the centres of the brain and spinal cord, finally paralysing them. It produces death by paralysis of respiration, according to Mosso, by causing tetanus of the respiratory muscles.

Symptoms.—The symptoms produced are pallor, cyanosis, faintness, and cold sweats, pain in the precordial region, rapid pulse, intermittent heart beat, laboured respiration. The pupils are dilated. Speech becomes incoherent, there may be trismus of the jaws, the ideas are confused, and there may be

delirium. Tetanic spasms of muscles may occur, and convulsions, also loss of consciousness.

Chronic poisoning, following the cocaine habit, produces a long series of symptoms which are manifestations of mental and physical degeneration, which in extreme cases may pass on to insanity, with hallucinations and delusions.

Fatal Dose.—Half a grain injected into the gum of an adult has caused alarming symptoms, and two-thirds of a grain has caused death. Recovery has taken place after forty-three grains were taken by the mouth.

Fatal Period.—Death has occurred in twenty minutes after three and a half grains by hypodermic injection.

Chemical Analysis.—The alkaloid may be separated from the stomach contents or viscera by the usual procedure for extraction of alkaloids.

1. On the addition of strong nitric acid and evaporating to dryness, the residue when treated with alcoholic solution of potash gives off an odour like peppermint or meadow-sweet.

2. *Goeldner's Test.*—Strong sulphuric acid and resorcin when mixed with cocaine gives a blue colour, changing to rose-pink on addition of caustic potash. Goeldner considers this a reaction peculiar to cocaine.

3. *Metzer's Test.*—If a few drops of a 5 per cent solution of chromic acid in water be added to a solution of cocaine hydrochloride, each drop gives a yellow precipitate which redissolves. The addition of strong hydrochloric acid produces a yellow precipitate of chromate of cocaine. Metzer considers this reaction peculiar to cocaine.

4. When applied to the tongue or lips a feeling of numbness is produced; it is rendered more effectual if a solution of sodium bicarbonate be first applied to the mucous membrane.

Treatment.—Wash out the stomach and encourage vomiting. Stimulants and ammonia should be given freely, and if convulsions occur chloroform should be inhaled. Tannic acid or gallic acid in thirty-grain doses have been recommended, also iodine one grain with potassium iodide ten grains, in a wine-glassful of water between the stomach-washing or emesis. Oxygen inhalations and artificial respiration may be resorted to in failure of the respiration.

COCCULUS INDICUS.

The fruit of Cocculus Indicus, *Anamirta paniculata* (*N. O. Menispermaceæ*), is poisonous, and is frequently used by poachers to capture fish. The berries are ground to powder, mixed with bread, and then thrown into the water. When taken by the fish, they become stupefied, float to the surface, and are then taken.

The poisonous properties are due to a crystalline alkaloid, *Picrotoxin.* Fraudulent publicans have used this drug for the adulteration of beer. The strength of the beer is first reduced by the addition of salt and water, and then the cocculus indicus is added, to give to it an intoxicating property. The effect produced on the unfortunate customers is a strong desire to sleep, with more or less wakefulness. Loss of voluntary power is present, but consciousness is not lost, the sufferer lying in a state bordering on nightmare. Cocculus is not used in medicine or the arts, and yet a large quantity is imported, and mysteriously disappears in this country.

Symptoms.—The symptoms which have been noticed in poisoning by this substance are—nausea, vomiting, severe abdominal pains, stupor, and intoxication. Two deaths at least have been reported as resulting from it. In the case of R. *v.* Cluderay, "the defendant administered to a child two cocculus indicus berries, entire in the pod, with intent to murder the child." The kernel is a poison; the pod is not, and will not dissolve in the stomach; and they were therefore harmless. This was held to be administering poison with intent to murder, within the section of the Statute.

Picrotoxin, the alkaloid, is in fine white crystals, intensely bitter to the taste, soluble in boiling water, slightly so in cold. Alcohol and ether readily dissolve it. Strong nitric acid dissolves it, without change of colour; and sulphuric acid produces an orange-yellow colour, changed to pale yellow by dilution. In organic liquids it might be mistaken for sugar, or *vice versa,* as it precipitates the oxide of copper when boiled with the sulphate of copper and potash. In examining beer supposed to be adulterated with picrotoxin, the beer should be acidulated with hydrochloric acid, and then shaken up with ether. On spontaneous evaporation of the ether, the picrotoxin is left in crystals.

Treatment.—Stomach pump, emetics, apomorphine subcutaneously; then chloral and the bromide of potassium. Chloroform may be inhaled. Paraldehyde is said to be a specific antidote.

LOLIUM TEMULENTUM.

The seeds of *Lolium temulentum*, or common darnel, are poisonous. Cases of poisoning have occurred from these seeds being accidentally ground with wheat or rye, and then made into bread.

Symptoms.—Gastric irritation, nausea, and vomiting followed by giddiness, deafness, loss of vision, and, in some cases, delirium. Not infrequently the symptoms resemble those produced by ergot. No death has been recorded as resulting from the use of these seeds. Three ounces of paste made from darnel flour, given to a dog, did not cause death.

POISONOUS FUNGI.

Accidental poisoning by mushrooms is by no means rare. The *Agaricus campestris*, and a few others, are edible; but it is a fact worthy of notice that the poisonous properties of mushrooms are modified by climate and the seasons of the year at which they are collected. Idiosyncrasy may have something to do with the injurious effects produced on some persons by the fungi.

The *Agaricus campestris*, or common mushroom of this country, is sometimes poisonous; and in some countries—Italy and Hungary—it is usually avoided. In Russia and in France certain fungi are eaten which are regarded as poisonous by us.

Bentley gives, in his *Botany*, the following Table, by which edible and poisonous mushrooms may be known:—

[TABLE

Edible.	Poisonous.
1. Grow solitary in dry airy places.	1. Grow in clusters in woods and dark damp places.
2. Generally white or brownish.	2. Usually with bright colours.
3. Have a compact, brittle flesh.	3. The flesh tough, soft, and watery.
4. Do not change colour by the action of the air when cut.	4. Acquire a brown, green, or blue tint when cut and exposed to the air.
5. Juice watery	5. Juice often milky.
6. Odour agreeable.	6. Odour commonly powerful and disagreeable.
7. Taste not bitter, acrid, salt, or astringent.	7. Have an acrid, astringent, acid salt, or bitter taste.

Symptoms.—Two sets of symptoms may follow the use of mushrooms as food—those of irritant and those of narcotic poisoning. In the latter class, giddiness, double vision, and even delirium, have been present. Nausea, vomiting, purging, and convulsions characterise those of the former class. In some cases the individual has presented all the appearances of intoxication.

Post-mortem Appearances.—These will depend to a great extent upon the character of the symptoms prior to death. If signs of irritation have been present, inflammation of the stomach and bowels will most probably be found; but if, on the other hand, narcotic symptoms were predominant, congestion of the vessels of the brain will most likely be present. Arsenic and other poisons have been mixed with mushrooms with intent to kill; the probability of this occurring should be borne in mind, and a rigid examination of the contents of the stomach made in all doubtful cases.

Treatment.—Castor oil and emetics, atropine hypodermically.

NITROBENZENE, OR ESSENCE OF MIRBANE.

This substance, prepared by acting on benzene by nitric acid, is largely used for flavouring sweets, etc. Nitrobenzene is a heavy, yellow, oily substance with a strong odour of bitter-almond oil, from which, however, it differs by undergoing no change of colour when agitated with strong sulphuric acid. The natural oil acquires a fine crimson colour when treated with strong sulphuric acid.

Symptoms.—These may not make their appearance for three or four hours after the poison is swallowed or inhaled. The vapour is more powerful than the liquid. In some cases which have been described, the patient has complained of feeling drunk, with pain in the head, giddiness, faintness, distorted vision, drowsiness, ending in coma and death. The face is flushed, the jaws sometimes spasmodically closed, and the lips livid. Vomiting then supervenes, the vomited matters having the odour of bitter almonds. Symptoms not unlike those produced by prussic acid or the essential oil of bitter almonds have been noticed in one or two cases; but, as a rule, the insensibility is not immediate, as in prussic acid poisoning, and in this fact lies the distinction between the two substances. Rapidly fatal cases might be mistaken for apoplexy, but the odour betrays the cause of death.

Post-mortem Appearances.—Nothing very characteristic is found after death due to this poison. The blood is sometimes black and fluid and gives the spectrum of acid hæmatin, the lungs congested, and the liver of a purple colour. The blood, contents of the stomach, and even the tissues, may smell strongly of this substance.

Chemical Analysis.—Nitrobenzene may be separated by distilling the organic mixture with sulphuric acid, when the distillate will contain the poison if present. It is converted into aniline by heating it with acetic acid and iron filings. (See test for aniline, *infra.*) On account of its odour, the only substance with which it can be confounded is the essential oil of bitter almonds, which owes its poisonous properties to the prussic acid it contains.

THE FOLLOWING TABLE MAY ASSIST IN ITS DETECTION.

	NITROBENZENE.	OIL OF BITTER ALMONDS.
Strong sulphuric acid .	No change of colour.	A rich crimson colour.
Proto-sulphate and the persulphate of iron, liquor potassæ, and hydrochloric acid.	No blue colour.	Prussian blue.
Solution of sulphate of soda.	Insoluble.	Soluble.

Treatment.—Stomach pump, emetics, stimulants, cold douche, artificial respiration.

DINITROBENZENE.

This substance is a solid of a yellow colour, and is used in the manufacture of *roburite*, *bellite*, and *sicherite*, explosives used in coal mines for blasting. Poisoning by it occurs amongst the workmen who come in contact with it in factories where it is used, by inhaling either the vapour or fine particles, and by handling it may become absorbed through the skin.

Symptoms.—In acute cases these are similar to poisoning by nitrobenzene. In chronic poisoning there is a marked and peculiar pallor of the face, with a livid blue colour of the ears, lips, fingers, and toes. Nausea and vomiting occur, with weakness, giddiness, and staggering. Amblyopia is a common symptom, with concentric contraction of the visual field and central scotoma. The blood resembles that of pernicious anæmia, and the urine is brown or blackish, due to some pigments of the aromatic series.

Post-mortem Appearances.—The blood has been found chocolate-coloured, and ecchymoses have been noted in mucous membranes.

Treatment.—As for nitrobenzene.

ANILINE.

Aniline is a colourless oily liquid gradually changing to brown on exposure to air. The various aniline dyes are obtained by oxidation of aniline. Aniline is produced by reduction of nitrobenzene. It is slightly soluble in water, freely so in alcohol or ether. It can be absorbed through the unbroken skin as well as by the lungs and mucous membranes. It is used in the manufacture of marking inks. It has very toxic properties.

Symptoms.—The symptoms come on rapidly—nausea and vomiting, with giddiness and drowsiness; the lips, face, ears, fingers, toes, conjunctivæ and mucous membranes become cyanotic. The respirations are slow and laboured. The pulse may be full and slow, or small and irregular. The body surface is cold, the pupils react sluggishly to light. The blood is chocolate-coloured, and is said to give the spectrum of

methæmoglobin. The blue colour is held to be due to pigment changes, and not to true cyanosis. Convulsions and coma may come on in fatal cases.

Buchanan met with a case of aniline poisoning in a man who by mistake swallowed about half an ounce of marking ink. Vomiting came on early, with giddiness and staggering gait. The body became changed in colour very rapidly—the colour being between a slate and leaden hue. The eyeballs were of the same colour but of a lighter shade, the mouth and tongue exhibited the colour most markedly. The temperature was subnormal, the pulse quick and feeble, and the breathing occasionally interrupted with sighing respirations. The blood failed to give the spectrum of methæmoglobin. The symptoms passed off within twenty-four hours. During the illness the man passed several green-coloured motions. The vomit was of a purplish-black colour—from the marking ink—and on analysis gave the reactions of aniline. Some of the ink was procured, and on being analysed was found to consist of hydrochloride of aniline and chloride of copper. The treatment consisted of stomach lavage and inhalations of oxygen, which gave the patient much relief.

Cases have been recorded of aniline poisoning in infants from absorption of the material from linen napkins, which were stamped with marking ink. Buchanan has seen lividity arise from the dry hydrochloride of aniline having been carried in a paper parcel in the waistcoat pocket for two or three days.

Post-mortem Appearances.—None characteristic.

Fatal dose.—Six drachms have proved fatal, probably less might do so.

Chemical Analysis.—Aniline may be separated from organic matter by alkalising and distilling the mixture.

1. If chloride of lime (bleaching powder) be added slowly to an aqueous solution of aniline, a deep purple colour is produced, which changes to brownish-red.

2. If strong sulphuric acid be added to aniline in a porcelain capsule it forms a dirty-white mass; on adding water and then potassium bichromate a bronze-green colour is produced, which changes rapidly to blue and then black.

3. If aniline be dissolved in excess of aqueous solution of phenol, and bleaching powder dropped into the mixture, a yellow streak changing to blue follows each drop.

4. Heated with corrosive sublimate a rich crimson colour is produced.

5. If aniline be mixed with a little chloroform and alcoholic solution of potash and heated, the peculiar odour of phenyl-isocyanide is given off.

Treatment.—As for nitrobenzene.

FUSEL OIL, AMYLIC ALCOHOL, POTATO-SPIRIT.—Fusel oil, also known as amylic alcohol, is known by its unpleasant odour and burning taste; it acts like alcohol as an inebriant, giving rise to headache, giddiness, etc.

NITRO-GLYCERINE.—In liquid or vapour, violent headache and throbbing in the temples are produced by this substance, which is used in the treatment of angina pectoris.

ANTIFEBRIN AND ANTIPYRIN (PHENAZONUM).

These substances are used extensively as antipyretics. They have been known to cause poisoning when administered in large doses.

Symptoms.—The symptoms are principally those of depression, impairment of sight, vertigo, sleepiness and unconsciousness; collapse, cyanosis, and loss of body temperature; the pulse and respiration are lowered. Antipyrin causes tumultuous action of the heart, and there may be erythematous or herpetic eruptions on the skin.

Chemical Analysis.—Antifebrin may be extracted from an acid solution by chloroform; for antipyrin the solution should be alkaline.

Antifebrin gives the phenyl-isocyanide reaction on warming with alcoholic solution of potash and chloroform. Bichromate of potassium dissolved in strong sulphuric acid gives a red colour, changing to brown and dirty-green; sodium nitrite and strong hydrochloric acid give a yellow colour, changing to green and blue; on evaporation the residue is orange, and turns red on addition of ammonia.

Antipyrin.—Heated with strong nitric acid and the liquid allowed to cool, a purple colour is produced; if water be added a violet precipitate is thrown down, and the filtered liquid will be purplish-red. Ferric chloride gives a blood-red colour, destroyed by a mineral acid. An aqueous solution of potassium nitrite and strong sulphuric acid gives a green colour.

CHAPTER XI.

SEDATIVE POISONS.

Cardiac.

DIGITALIS.

The common foxglove, *Digitalis purpurea* (*N. O. Scrophulariaceæ*), grows wild in the hedges in the South of England. All parts of the plant are poisonous, from the presence of a glucoside *digitalin*, and in addition it also contains the glucosides digitoxin, digitonin, and digitalein; according to Kopp, digitoxin is six to ten times more toxic than digitalin.

Symptoms.—Nausea, salivation, vomiting, purging, and severe abdominal pains are first noticed. The patient then complains of pain in the head, giddiness, and a gradual loss of sight. The eyes protrude, the pupils are dilated and insensible to light, and the sclerotics, according to Tardieu, are of a characteristic blue colour; the pulse weak, slow (forty in the minute), and jerky, sometimes intermittent. The surface of the body is cold, and bathed in perspiration. An aggravation in the symptoms takes place whenever the patient attempts to leave the recumbent position; hence, in all cases of poisoning, and in those where the therapeutical action of the drug is sought, the patient should be warned of the danger of leaving the recumbent posture. A marked depression in the action of the heart is a characteristic effect of this poison. The effect on the heart may be divided into three stages: (1) diminution in the frequency of the pulse, and rise of arterial pressure; (2) both of these become abnormally low; (3) frequency of pulse abnormally high, arterial pressure abnormally low. Convulsions have sometimes been noticed, and syncope and stupor are not uncommon.

Post-mortem Appearances.—Congestion of the brain and its membranes, and some inflammatory redness of the mucous membrane of the stomach. The blood is fluid.

Fatal Dose.—Uncertain. Large doses of the infusion and tincture have been given without any untoward results. Thirty-eight grains of the powdered leaves, and nine drachms of the tincture have proved fatal. One-quarter to half a grain of digitalin might prove fatal to an adult.

Fatal Period.—From three-quarters of an hour to twenty-four hours.

Chemical Analysis.—If the leaves in an infusion be taken, these must be sought for and examined. The glucoside may be extracted by first removing the impurities by means of petroleum ether, then acidifying with acetic acid and extracting with chloroform.

The following are the tests for *digitalin* :—

1. An almost amorphous, white, or fawn-coloured inodorous substance.
2. Almost insoluble in water.
3. Decomposes nitric acid, with the evolution of nitrous acid fumes. An orange-yellow-coloured solution is formed, which, in a few days, assumes a golden-yellow tint.
4. Sulphuric acid dissolves it, changing it to a reddish-brown colour, changed to violet by bromine vapour.
5. Hydrochloric acid with it at first forms a yellow solution, which, when heated, changes to a bright-green colour.

The physiological test may be employed by injecting a solution of a carefully prepared extract of the contents of the stomach or vomited matters under the skin of a frog, dog, or rabbit.

Treatment.—Purgatives and emetics should be given, followed by infusions containing tannin, green tea, oak bark, galls, strong coffee, and other stimulants. The patient should be kept in the recumbent posture, and on no account allowed to sit up.

TOBACCO.

The consumption of tobacco, *Nicotiana Tabacum* (*N. O. Solanaceæ*), has greatly increased of late years. In some countries its use was prohibited by stringent laws. In Russia amputation of the nose was the punishment. Several Popes have excommunicated those who smoked in St. Peter's at Rome ; and in some parts of Switzerland it was ranked on the

tables next to adultery. Amurath IV. made smoking tobacco a capital offence. Be this as it may, the moderate use of tobacco does not appear to lead to injurious results; and it is found that workmen engaged in the manufacture of tobacco do not suffer from any diseases other than those affecting the generality of mankind.

Nicotine—the alkaloid—is a colourless or slightly amber-coloured, oily, volatile liquid. It is to this principle that the poisonous activity of the drug is due. It differs from the other oily alkaloid, *conine*, in appearing of a green colour when a drop is placed on the surface of white enamelled glass—conine having a *pink* colour. They both leave a greasy stain on paper. Nicotine has been detected by Stass' process in the tongue, stomach, lungs, and liver. A ptomaine not unlike nicotine has been discovered.

Symptoms.—Symptoms of poisoning by tobacco are by no means uniform, and have been variously described by observers. As a type of the effects produced, the following may be noticed as occurring to the tyro after his first or second "pipe": The pulse is primarily quickened; then follow nausea and faintness, accompanied with an intense feeling of sinking. The face is blanched, the pulse slow; perspiration stands on the forehead, and ultimately he vomits, and then gradually recovers. Cold air blowing on the face, or sponging the face with cold water, materially hastens a return to comfort. Sometimes, as in the case related by Dr. Marshall Hall of a man who smoked two "pipes," nausea, vomiting, and syncope occurred, followed by stupor, stertorous breathing, general spasms, and insensibility of the pupil. After an interval of a few hours, the above symptoms again returned, but from which the patient ultimately recovered. Death has resulted as a sequence to excessive smoking. Gruelin records two cases—one from seventeen, the other from eighteen pipes smoked at a sitting. The symptoms after taking nicotine are more acute, and are a burning acrid taste in the mouth and throat, nausea, vomiting, unconsciousness, shock, sighing respirations, delirium, convulsions; the pupils first contracted then dilated.

The filthy habit of snuff-taking has also been accredited with one or two deaths. Santeuil, the French poet, died in two days from the effects of snuff mixed with his wine as a practical joke.

In animals, the symptoms are—nausea, vomiting, purging, convulsions, stupor, and death. The heart becomes paralysed. One drop of the empyreumatic oil on the tongue of a cat killed it in two minutes, the animal dying in convulsions.

Post-mortem Appearances.—These are by no means uniform or characteristic. If much vomiting precedes death, the vessels of the brain may be engorged with blood. Inflammation of the stomach and intestines is also present in some cases. The odour of nicotine may be detected in the vomit or the stomach contents.

Fatal Period.—The symptoms soon make their appearance, and death has occurred in three-quarters of an hour, or even less,—in three minutes after taking the nicotine, in fifteen minutes after enema of tobacco.

Fatal Dose.—One to three drops of nicotine would probably kill an adult in a few minutes; an enema containing half a drachm of the leaves has proved fatal.

As an enema, tobacco should be used with extreme care.

Chemical Analysis.—Nicotine obtained by the usual process for alkaloid extraction, and mixed with water, may have the following tests applied after solution in dilute hydrochloric acid:—

1. Chloride of platinum gives an orange-yellow crystalline precipitate.
2. Corrosive sublimate, a white crystalline precipitate.
3. Arsenio-nitrate of silver, a yellow precipitate.
4. Caustic potash added to the hydrochloride and warmed causes a strong odour of tobacco.
5. Solution of iodine in ether added to ethereal solution of nicotine is followed by the production of long needle crystals after some hours.

Treatment.—Promote vomiting, wash out the stomach, cold water douches, and stimulants. Inject strychnine hypodermically.

LOBELIA.

Lobelia, or Indian Tobacco, *Lobelia inflata* (*N. O. Lobeliaceæ*), is extensively employed in North America in the treatment of asthma. The plant is officinal in the British Pharmacopœia, of which there are two preparations—a simple and an ethereal tincture. In small doses it possesses expectorant properties.

Symptoms.—Nausea, vomiting, giddiness, cold clammy sweats, and great depression. The pulse becomes irregular, and very feeble. Taken together, the symptoms are not unlike those produced by tobacco.

Fatal Period.—One to two days, or more.

Fatal Dose.—One drachm of the powder.

Chemical Analysis.—The alkaloid is fluid and may be extracted like nicotine; with it (1) strong sulphuric acid gives a red colour; (2) sulphomolybdic acid gives a violet colour.

Treatment.—The same as recommended under tobacco. Stimulants should be given, ether hypodermically or alcohol *per rectum.*

VERATRINE.

The alkaloid *Veratrine* is obtained from the dried fruit of *Asagrœa officinalis* (*N. O. Melanthaceæ*).

The alkaloid is in the form of a white amorphous powder, bitter and acrid to the taste. It acts as a powerful errhine, causing violent sneezing. Insoluble in water, it is readily dissolved by alcohol, ether, and chloroform. When gently heated on a plate with strong sulphuric acid, it first turns yellow, then crimson. Veratrine is entirely dissipated by heat.

Two grains of the alkaloid killed a cat in one minute; a dog being destroyed in two hours by a dose of three grains. The one-sixteenth of a grain (?) of veratrine in a pill caused alarming symptoms in an adult woman, for whom it was ordered by a medical man.

Symptoms.—Acrid burning sensation in the throat and down the œsophagus to the stomach, vomiting, great thirst, diarrhœa may occur with tenesmus. The pulse is feeble and respiration slow. The pupils may be dilated or contracted. Collapse and twitching of muscles, loss of consciousness and convulsions, or delirium and stupor may come on.

Post-mortem Appearances.—Are the same as in poisoning by any of the vegetable irritants.

Treatment.—Stomach pump, and emetics. Astringent infusions should be given, and alcohol and opium administered if the condition of the patient seems to require them.

Chemical Analysis.—Extract in the usual way for alkaloids.

1. Strong sulphuric acid produces a yellow colour, changing to red, produced rapidly if heated.

2. Strong hydrochloric acid and heat produces a red colour.
3. Sulphomolybdic acid produces a reddish colour, changing to dirty-brown, greenish, and finally blue.

These tests should be done with the solid veratrine.

HYDROCYANIC ACID.

Deaths by hydrocyanic acid are more numerous than those occasioned by any other poison, except opium and its preparations. Hydrocyanic acid is a compound of cyanogen and hydrogen. It was first obtained by Scheele in 1782, but it was not until 1815 that Gay-Lussac pointed out its real nature. Anhydrous hydrocyanic acid may be obtained by passing over cyanide of mercury, gently heated, a stream of dry sulphuretted hydrogen. It is now made by mixing ferro-cyanide of potassium with dilute sulphuric acid, and applying heat, when the acid is distilled over and collected in a cooled receiver.

Dilute hydrocyanic acid, the only important form of the acid from a toxicological point of view, is a colourless, feebly acid liquid, with a peculiar odour, like that of bitter almonds or peach kernels (specific gravity, 0·997). The Pharmacopœial acid contains 2 per cent of anhydrous acid; that of Scheele 5 per cent. According to Taylor, however, the percentage of the acid varies from 1·3 to 6·5. Taking into consideration the smallness of the dose, and the shortness of the time before death occurs, it is the most deadly of all known poisons. Prussic acid is not regarded as a cumulative poison—that is, it does not gradually accumulate in the body and then break out with dangerous or fatal violence.

Symptoms.—These will be more or less modified by the quantity of the dose, and in some cases closely resemble an attack of epilepsy. In most cases, the symptoms of poisoning are seldom delayed beyond *one* or *two* minutes; and if the dose be large, the symptoms of poisoning may come on while the person is drinking. Giddiness, followed by almost complete insensibility, mark the accession of the symptoms. The eyes are fixed, staring, and glassy; the pupils are dilated, and insensible to light. The muscles of the extremities are relaxed, and the limbs flaccid. A white or bloody froth surrounds the mouth, and the jaws are fixed. The surface of the body is cold and clammy to the touch; the respiration is sometimes long-drawn and spasmodic; and the pulse so

reduced as to be almost imperceptible. The breathing is sometimes *stertorous* in character. This is an important fact; for, in ignorance of the occasional presence of this symptom, it was argued that Walter Palmer, whose breathing was stertorous, died of apoplexy, and not from prussic acid as was alleged. When the dose is small (between twenty and thirty drops of the dilute acid), the patient complains of nausea, giddiness, and a feeling of constriction round the head. The mind is confused, the pulse hurried, and the breathing irregular. Salivation may also be present. Tetanic spasms and involuntary evacuations precede the fatal termination. When the dose is from ten to twenty drops, the patient complains of nausea, giddiness, and a feeling of impending suffocation. These symptoms under treatment may soon pass off, or leave the patient more or less confused and listless. In most cases, where the dose is very large, death takes place suddenly, without convulsions; but the period of death does not appear to be as short in man as in the lower animals.

External Application.—Applied to the unbroken skin, prussic acid does not appear to have caused any alarming symptoms; but it should be used with the utmost caution where the skin is at all abraded or ulcerated.

Post-mortem Appearances.—In making an inspection, care should be taken; for, if the dose be large, the vapour from the corpse on opening it has been known to produce giddiness and fainting. Externally, the skin is pale, livid, or of a violet colour. The hands are clenched, and the nails blue. The jaws are firmly set, and there is usually some froth round the mouth. The internal organs are greatly congested, and the venous system gorged with fluid dark-coloured blood. The stomach and intestines are sometimes inflamed, but in many cases they present no material alteration in colour.

The appearances, when only a small dose has been taken, are not unlike those of asphyxia. The detection of the odour of hydrocyanic acid in the body is of importance; but this may be absent from the following causes:—

1. Smallness of the quantity of the acid present.
2. Volatilisation from exposure of the corpse to the air.
3. The smallness of the dose, and its absence the result of absorption and elimination, if death has not rapidly taken place.
4. The amount of dilution of the poison.
5. Concealed by other odorous substances.

In some cases, the smell may be detected in the stomach seven or eight days after death. The viscera should, in all cases of suspected poisoning, be placed in a glass-stoppered jar, and the stopper covered by bladder and tinfoil. Hydrocyanic acid is so volatile that, unless the greatest care be taken, all traces of it may vanish; and thus the guilty person may be allowed to escape.

Fatal Period.—From a few seconds to as many minutes. Under active treatment, if a patient survive forty minutes, he will generally recover.

Fatal Dose.—Thirty minims of the dilute acid of the Pharmacopœia. This contains six-tenths of a grain of the anhydrous acid. Recovery has, however, taken place even after comparatively large doses. The strength and age of the individual, and also the emptiness or fulness of the stomach at the time the poison is swallowed, will materially affect the issue.

Experiments on Animals.

Numerous experiments on animals have been made to ascertain the rapidity with which prussic acid kills. The late Sir R. Christison found that three drops projected into the eye acted on a cat in twenty seconds, and killed it in twenty more. The same quantity dropped on a fresh wound in the loins acted in forty-five, and proved fatal in one hundred and five seconds. In the cases where death did not occur so rapidly, there were regular fits of violent tetanus; but in the very rapid cases, the animals perished, just as the fit was ushered in, with retraction of the head. In rabbits opisthotonos, in cats emprosthotonos, were the chief tetanic symptoms.

As a proof that the acid acts equally on the brain and spinal cord, may be noticed the presence of coma and tetanus in some cases of poisoning by this substance.

In the experiments on animals certain effects were noticed, which are as follows:—

Expulsion of the Fæces and Urine.—In some cases only the fæces, in others the urine alone, was involuntarily expelled; and in some other cases neither the one nor the other was present.

The Shriek or Cry.—This cry, though a common, is by no means a constant symptom.

Convulsions.—These are sometimes present.

Acts of Volition.—Only slight acts are possible; in the case of one of the dogs experimented on by Mr. Nunneley, the animal "went down, came up, and then went down again the whole flight of a steep, winding staircase."

The *Post-mortem Appearances* were not well marked in the animals subjected to experiment. In chronic cases, Mr. Nunneley states that

both sides of the heart were distended with black blood. The pure acid is stated to completely destroy the irritability of the heart and voluntary muscles, galvanism producing no effect whatever. "In eight experiments on cats and rabbits with the pure acid, the heart contracted spontaneously, as well as under stimuli, for some time after death, except in the instance of the rabbit killed with twenty-five grains, and one of the cats killed by three drops applied to the tongue. In the last two the pulsation of the heart ceased with the short fit of tetanus which preceded death ; and in the rabbit, whose chest was laid open instantly after death, the heart was gorged, and its irritability utterly extinct."

Detection of Hydrocyanic Acid in Cases of Poisoning.

The "*Vapour Tests*" are those most readily applied to organic mixtures ; but in some cases it may be necessary to make a distillation of the suspected substance, in order to isolate the poison.

The first point to be noticed is, whether any *odour* of the acid can be perceived in the substance under examination. In any case, the contents of the stomach or finely-divided tissues should be mixed with water, and examined as to the reaction with test paper. If the mixture be found to be *alkaline*, it must be neutralised by the addition of tartaric acid ; if, on the contrary, it be *acid*, carbonate of soda must be carefully added to neutralisation. A state of neutrality is always necessary previous to distillation, for the following reasons :—

An *alkaline* state of the liquid would, on the one hand, prevent, or, at all events, retard, the evolution of the hydrocyanic acid ; whilst, on the other, the existence of any *free acid* would decompose any cyanide which might be present, and thus give rise to an evolution of hydrocyanic acid not existing as such in the mixture.

The organic mixture is then placed in a flask, and the contents distilled at as low a temperature as possible by the aid of a water bath.

Should hydrocyanic be present, the distillate will yield all the characteristic reactions of the dilute acid.

1. Nitrate of silver will give a curdy-white precipitate, insoluble in cold but soluble in boiling nitric acid. A portion of the precipitate, on the addition of some liquor potassæ, sulphate of iron, ferric chloride and hydrochloric acid, forms Prussian blue. In this test, which may be taken as quite conclusive, the

hydrochloric acid decomposes the cyanide of silver; and on the addition of the sulphate of iron, Prussian blue is formed.

2. If a portion of the dry precipitate formed by the nitrate of silver be heated in a test tube, cyanogen gas will be evolved, known by its characteristic odour of peach blossoms, and by its burning at the mouth of the tube with a rose-coloured flame.

3. To the solution containing hydrocyanic acid add a few drops of potassium nitrite, two or three drops of ferric chloride solution and dilute sulphuric acid until a yellow tint is obtained; heat to boiling, cool, precipitate excess of iron with ammonia, filter, and add one or two drops of a very dilute solution of colourless ammonium sulphide. A very minute quantity of hydrocyanic gives a violet-red colour, changing to blue, green, and finally yellow.

4. If a solution of starch be tinged blue with iodine, the colour will be discharged by a minute quantity of hydrocyanic acid.

Vapour Tests.—There are three tests for the presence of hydrocyanic acid when present in organic mixtures, which have the advantage of being applicable without the addition of anything extraneous to the mixture to be tested. They are all dependent on the volatile nature of hydrocyanic acid, and may be applied as follows, the suspected mixture being divided into three portions:—

1. *Iron or Prussian Blue Test.*—The liquid mixture to be tested is placed in a small beaker glass, and covered with a glass plate the centre of which is smeared with a mixture of potash and proto-sulphate of iron. The whole is now left undisturbed for some time. The glass is eventually removed, and the mixture of potash and iron treated with hydrochloric acid, which, should hydrocyanic acid be present, will cause the development of Prussian blue.

2. *Sulphur Test, or Liebig's Test.*—A second portion of the original mixture is placed in a beaker, and a watch-glass containing a few drops of bisulphide of ammonium is suspended over the liquid, the mouth of the beaker being closed. A short time is allowed to elapse; the watch-glass is then removed, and its contents evaporated to dryness at a low temperature. A blood-red colour is developed on the addition of a little perchloride of iron to the *dry* residue. This effect is due to the absorption of the hydrocyanic acid vapour by the bisulphide of ammonium—sulphocyanide of ammonium being

formed, which, on the addition of perchloride of iron, gives the blood-red colour of the sulphocyanide of iron, which is bleached by corrosive sublimate.

3. *Silver Test.*—This is the most successful of the vapour tests, a single apple pip yielding all the reactions. If a watch-glass containing a few drops of nitrate of silver solution be suspended in a beaker (as in 2), the silver solution will become white and opaque, from the formation of cyanide of silver;

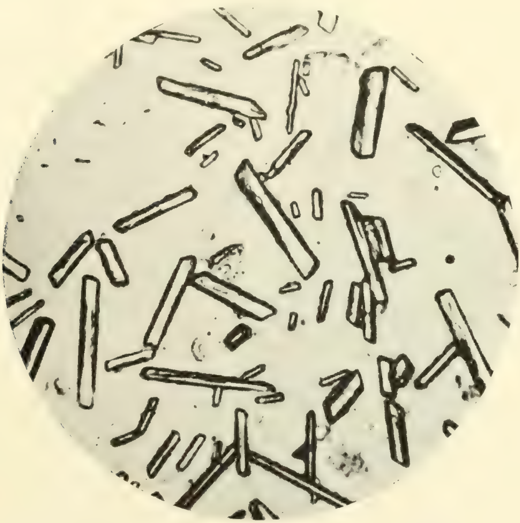


Fig. 34.—Photo-micrograph of crystals of cyanide of silver obtained by the vapour test, ×50. (R. J. M. Buchanan.)

examined under the microscope it is seen to consist of small prismatic crystals. The cyanide as formed, treated with hydrochloric acid, liquor potassæ, and sulphate of iron, will give Prussian blue.

The Quantitative Analysis.—Use the precipitate of cyanide of silver, 100 grains being equal to 20·33 of pure anhydrous acid.

Treatment.—The treatment of poisoning by prussic acid is now to be considered. As part of the general treatment,

the stomach pump should be at once employed, and the stomach emptied and then washed out with water.

Ammonia.—The use of this substance was first advocated by Mr. John Murray of London, and is no doubt a valuable remedy if given early. Care should be taken that the mucous membrane of the air passages and alimentary canal be not inflamed by using too strong a solution.

Chlorine.—Recommended by Riauz in 1822. Water impregnated with the vapour of chlorine may be given internally, and the gas may be breathed under proper precautions.

Cold Affusion.—First proposed by Dr. Herbst of Göttingen. Its success is most to be looked for when it is employed before the convulsive stage of the poisoning is over. The cold water should be poured on the head and down the spine.

Bleeding from the Jugular Vein.—In one case treated by Magendie, bleeding from the jugular vein was attended with success.

Chemical Antidotes.—The administration of a solution of carbonate of potash, followed by a solution of the mixed sulphates of iron, has been suggested. The formation of Prussian blue is the result. The only objection to this treatment is, that prussic acid is so rapidly absorbed that death may result from the already absorbed acid before the antidote can be given.

Atropine.—This should be given hypodermically.

Peroxide of hydrogen should be given freely by means of the stomach tube.

Cyanide of Potassium.

This substance is used largely by photographers and electroplaters. It acts as a poison in a similar manner to hydrocyanic acid, and the symptoms are the same. As a commercial preparation it frequently contains undecomposed potassium carbonate, and may exert a corrosive action on the mucous membranes of the mouth and stomach, leading to the production of blood-stained mucus in the stomach.

Post-mortem Appearances.—These are the same as those described under hydrocyanic acid, with the addition of the corrosive effects.

Fatal Dose.—Five grains have proved fatal in a quarter of an hour; recovery has taken place after forty grains.

Chemical Analysis.—Same as for hydrocyanic acid.
Treatment.—As for hydrocyanic acid.

PREPARATIONS CONTAINING HYDROCYANIC ACID.

The following plants contain prussic acid, and are therefore more or less poisonous in proportion to the quantity of the acid which they severally contain :—

NAT. ORD. ROSACEÆ.

Amygdalus Communis.—The Almond and its varieties.
Prunus Domestica.—The Plum and its varieties.
Cerasus.—The Cherry and its varieties.
Pyrus Aria, or White Bean Tree.—The seeds are poisonous.

NAT. ORD. EUPHORBIACEÆ.

Jatropha Manihot, or Bitter Cassava.

Bitter Almonds.

The essential oil of bitter almonds is very poisonous. "The oil does not, like common essential oils, exist ready formed in the almond, but it is only produced when the almond pulp comes in contact with water. It cannot be separated by any process whatever from the almond without the co-operation of water—neither, for example, by pressing out the fixed oil, nor by the action of ether, nor by the action of absolute alcohol. After the almond is exhausted by ether, the remaining pulp gives the essential oil as soon as it is moistened ; but if it is also exhausted by alcohol, the essential oil is entirely lost. The reason is, that alcohol dissolves out a peculiar crystalline principle named *Amygdalin*, which, with the co-operation of water, forms the essential oil by reacting on a variety of the albuminous principle in the almond, called *Emulsin*, or *Synaptase.*

The essential oil of bitter almonds may contain from 6·0 to 14·33 per cent of hydrocyanic acid. Deaths from the incautious use of this oil for flavouring articles of confectionery are not infrequent. As the flavour is not in the least injured, it has been suggested to subject the oil to repeated distillation with caustic potassa, by which means the oil is purified from prussic acid.

Symptoms in Man.—Nausea, vomiting, and diarrhœa, due to gastric irritation, have occurred when the dose has been small, as is the case when confectionery owes its flavour to the use of the essential oil. Idiosyncrasy may have something to do with these effects, for cases are on record where a single almond has produced a state resembling intoxication, followed by an eruption not unlike urticaria or nettle-rash. Taken in large doses, the symptoms produced are identical with those described under poisoning by prussic acid. The breath is usually strongly impregnated with the odour of bitter almonds.

Symptoms in Animals.—Vomiting, trembling, weakness, paralysis, tetanic convulsions, and coma.

Post-mortem Appearances.—These are identical with those seen in poisoning by the pure acid.

Fatal Dose.—The essential oil is from four to eight times as strong as the acid of the Pharmacopœia. From twenty to thirty drops have proved fatal. Death may take place in half an hour or less.

Treatment.—The same as that recommended under prussic acid.

Cherry-Laurel.

The cherry-laurel, *Prunus Lauro-cerasus*—the leaves of which have been used for flavouring custards, etc.—contains prussic acid, and is therefore poisonous.

In the British Pharmacopœia there is an *Aqua Lauro-cerasi*—laurel water—prepared from the leaves. It contains 0·1 per cent of hydrocyanic acid. It should be used with extreme caution, as the amount of hydrocyanic acid contained in the leaves is uncertain. Death has frequently resulted from its use. The most important case, however, is that of Sir T. Broughton. His mother, who gave him his usual draught on the morning of his death, observed that it had a strong smell of bitter almonds. Two minutes after he took it she observed a rattling or gurgling in his stomach; in ten minutes more he seemed inclined to doze; and five minutes afterwards she found him quite insensible, with the eyes fixed upwards, the teeth locked, froth running out of his mouth, and a great heaving at his stomach, and gurgling in his throat. He died within half an hour after swallowing the draught. No light was thrown on the case by the carelessly conducted *post-*

mortem; but the suddenness of his death, the improbability of apoplexy occurring at so early an age, and the odour of bitter almonds observed by his mother, pointed out clearly enough the true cause of death.

ACONITE.

All parts of this plant, the *Aconitum Napellus* (*N. O. Ranunculaceæ*), are poisonous. The poisonous properties depend upon the presence of an alkaloid—*aconitine*—chiefly found in the root.

Poisoning by the alkaloid came before the public mind in the case of Dr. Lamson, executed for the murder of his brother-in-law. The symptoms noticed in that case were very much as detailed below. When any part of the plant is chewed, a sensation of tingling is experienced in the mouth, and burning in the throat. Many of the aconites are, however, inert. The root, having been taken by mistake for horse-radish, has led to several cases of accidental poisoning.

Aconite.	Horse-Radish.
General Characteristics. — Root conical; dark brown externally, and with numerous twisted rootlets; internally, the colour is whitish.	*General Characteristics.* — Root cylindrical, of nearly the same thickness down its whole length. Externally, buff-coloured; internally, white.
Taste.—Produces a tingling and numbing sensation in the mouth.	*Taste.*—Sweet and pungent.

Symptoms in Man.—The patient complains, within a short time after the poison is taken, of dryness of the throat, accompanied with tingling and numbness of the mouth and tongue. He then complains of nausea, vomiting, pain in the epigastrium, and distressing dyspnœa, of a sensation of formication or tingling, with numbness in his face and limbs, which appear to him heavy and enlarged. In attempting to walk he staggers, his limbs losing their power of supporting his body. He becomes giddy, his pupils dilated, and his sight and hearing imperfect; but he is seldom unconscious till near death. His pulse irregular, gradually becomes weaker, and at last almost imperceptible; his skin cold and clammy; his features pale and

bloodless; and his mind clear: then suddenly he dies, in some cases from shock, in others from asphyxia; or he may die from syncope, especially after some exertion.

Symptoms in Animals.—Weakness of the limbs and staggering, the respiration slow and laboured, loss of sensation, paralysis, dimness of vision, increasing difficulty in breathing, *convulsions*, and death by *asphyxia.*

Delirium is present in some cases, and dilatation of the pupil has also been noticed. In a case recorded in the *British Medical Journal*, 1877, vol. i. p. 258, two ounces of the tincture of aconite were drunk in mistake for *Succus Limonis;* recovery took place, but not before alarming symptoms had taken place, and death at one time appeared imminent.

Post-mortem Appearances.—General venous congestion. The brain and its membranes are, in most cases, found congested and the stomach and intestines inflamed.

Fatal Period.—The symptoms may come on immediately, or may be delayed for an hour or two. In the case mentioned in the *British Medical Journal* the patient walked about five miles after swallowing two ounces of the tincture, which he drank at 11 o'clock, returning home at 2.30 P.M. An excise officer, who died in about four hours, was able to walk from the Custom House over London Bridge. Death has taken place in so short a time as one hour and a quarter.

Fatal Dose.—About two grains of the extract, and one drachm of the tincture. Much will depend upon the amount of the alkaloid present. One drachm of the scraped root is said to have proved fatal. One-fifteenth of a grain of aconitine has proved fatal.

Chemical Analysis and Tests.—The alkaloid must be isolated from the contents of the stomach by the process of Stass. The physiological test consists in placing a small portion of the extract, or the alkaloid so obtained, on the tongue or lip, and noting if tingling be produced. To the pure alkaloid, nitric acid added produces no change of colour. Officinal phosphoric acid added, and the mixture carefully evaporated, a violet colour is produced; this reaction is due to impurities in the aconitine.

Kundrat's Test.—A solution of ammonium vanadate in strong sulphuric acid produces a coffee colour with aconitine.

Treatment.—Emetics, stomach lavage, castor oil, and animal charcoal should be given. The administration of digitalis in aconite poisoning has been attended with the most happy results. (See *British Medical Journal*, 11th December 1872.) The drug may be given hypodermically as an antidote. Stimulants will be required ; and friction down the spine, together with galvanism and artificial respiration, may be tried.

Synopsis of the Action of Aconite.

1. *On Nervous System.*—Giddiness, numbness, and tingling in the limbs is a primary effect, followed by gradually increasing paralysis of the muscles, and insensibility of the surface of the body to pinching and pricking. Dr. Fleming asserts that it produces a *powerful sedative effect on the nervous system.* At any rate, it now seems to be proved that aconite paralyses the sensory nerves, commencing at their peripheral endings.

2. *On Vascular System.*—Extreme depression of the circulation is produced by doses large enough to cause death. The pulse may become imperceptible at the wrist. In medicinal doses, aconite lowers the heart's action ; in poisonous doses, it causes fatal syncope.

3. *On Digestive System.*—Some have denied the irritant action of aconite on the alimentary canal, but Sir R. Christison states that he was deterred from the use of aconite "by two patients being attacked with severe vomiting, griping, and diarrhœa."

CHAPTER XII.

CEREBRAL POISONS.

The symptom most characteristic of these poisons is the marked anæsthesia which they produce when their vapours are inhaled. The hydrate of chloral, though placed under the above heading, is more closely allied in its action to opium than to ether or to chloroform.

ETHER.

Ether, when taken in its liquid form, produces symptoms and *post-mortem* appearances not unlike those caused by alcohol.

Fatal Dose.—No death having been recorded, the fatal dose of this substance is unknown.

Ether Vapour.—The vapour of ether has caused death. Entering the blood through the lungs, it acts with great rapidity, a state of lethargy being quickly induced.

The early symptoms are noticed in a modification of respiration, the breathing becoming slow, prolonged, and stertorous. The face is pale, the lips bluish, and the surface of the body cold and exsanguine. The pulse, at first quickened, becomes slower, as the inhalation of the vapour is continued. The pupils are dilated, and the eyes glassy and fixed. The voluntary muscles of the body become flabby and relaxed, the patient still, however, having the power to move the limbs. The involuntary muscles are not affected ; as an instance, the uterus contracts and expels its contents with ease. If the inhalation of the vapour be pushed too far, the pulse sinks, and coma ensues, from which the patient can only with difficulty be aroused ; but if in an early stage the ether be discontinued, the patient rapidly regains consciousness, due to the rapid

elimination of the ether by the lungs. A marked peculiarity in this form of poisoning is the complete anæsthesia or paralysis of the nerves of sensation.

Post-mortem Appearances.—These are chiefly found in the brain and lungs, which in most cases are greatly congested. The cavities of the heart have been found full of dark-coloured liquid blood. A marked effect noticed in poisoning by ether is the congestion of the vessels of the upper portion of the spinal cord. The liver, kidneys, and spleen are sometimes congested.

Chemical Analysis.—The contents of the stomach and tissues must be treated and distilled, as described under alcohol.

Tests :—

1. The vapour passed into a solution of bichromate of potash, and sulphuric acid added, gives the reactions of alcohol.
2. The vapour burns with a smoky flame, depositing carbon on any cool surface placed above the flame.
3. It is but sparingly soluble in water, on which liquid it floats.

Treatment.—When the pulse becomes weak, and the breathing laboured and stertorous, the inhalation should be discontinued, and cold water dashed in the face—free ventilation being also allowed. Galvanism and artificial respiration should also be tried.

CHLOROFORM.

The effects produced by chloroform when swallowed are not unlike those occasioned by alcohol. Four ounces have been taken without causing death; it is, therefore, not an active poison in this form.

Chloroform Vapour.—The symptoms occasioned by chloroform when inhaled are not unlike those caused by ether, with this exception, that insensibility and general relaxation of the muscles are more rapidly produced.

Symptoms.—The symptoms of poisoning when chloroform is taken by the mouth are similar to those following inhalation, with irritation of the mucous membrane of the stomach and intestines. Vomiting generally occurs, the person becomes unconscious and comatose, the face cyanosed and the skin moist. The pupils are dilated and insensitive to light. The breathing is slow and stertorous, the pulse small and feeble. Death is due to respiratory paralysis first, and paralysis of the heart in

addition, or the latter, according to some observers, may be the primary cause. On recovery diarrhœa may follow, with occasionally enlargement of the liver and jaundice.

Post-mortem Appearances.—Congestion of the vessels of the brain, and also of the lungs, is generally found. The cavities of the heart are usually empty; but, in some cases, the right side of the heart is found distended with dark-coloured fluid blood. Congestion of the spleen, liver, and kidneys is not of infrequent occurrence.

Fatal Period and Dose.—In one or two cases where the vapour was inhaled, death took place in from one to two minutes. Thirty drops thus taken destroyed life in one minute, and even fifteen drops have proved speedily fatal. It has thus destroyed life in a smaller dose, and more rapidly, than any other known poison. When swallowed, one fluid drachm has proved fatal in a boy, about four fluid drachms in an adult. Recovery has taken place after four fluid ounces. Three hours is the shortest fatal period after swallowing chloroform.

Chemical Analysis.—In searching for the presence of this substance in the blood or tissues, the examination should be made as speedily as possible, as chloroform is thought by some observers to have a great tendency to pass into formic acid, and thus to escape recognition.

1. The substance to be examined should be placed in a flask, to which is adapted a glass tube bent at right angles. A piece of blue litmus paper, and another portion of paper moistened with iodide of potassium and starch paste, are inserted into the end of the glass tube. The flask and its contents should now be placed in a water bath heated to a temperature of 161° F. (72° C.), and a portion of the glass tube just past the bend heated to redness. Any chloroform vapour evolved from the contents of the flask is decomposed during its passage through the heated glass tube into free chlorine and hydrochloric acid, the presence of the former being indicated by the starch paper becoming blue; while at the same time the reddening of the litmus paper reveals the presence of the acid. As a further corroboration, the exit-tube may be made to dip into nitrate of silver solution, when a precipitate of the curdy-white chloride of silver will take place, insoluble in nitric acid, but dissolving on the addition of

ammonia. Every 100 parts of chloride of silver formed, equals 27·758 of chloroform. By this process chloroform has been detected four weeks after death in putrid organs.

2. Chloroform may be separated from organic mixtures by distillation. If aniline and alcoholic solution of potash be added to chloroform and heated, the peculiar odour of phenyl-isocyanide is given off.

3. A solution of β-naphthol dissolved in caustic potash, when added to chloroform and heated, gives a blue colour.

Treatment.—The same as recommended with regard to ether. M. Nelaton recommends inversion of the body, and ascribes the recovery of one patient to his suddenly lifting him up and throwing him over his shoulder with his head hanging down.

CARBON BISULPHIDE.

This substance is largely used in certain industries, as it dissolves oils, fats, caoutchouc, gutta percha, etc. It is very inflammable, burns with a blue flame, evolving sulphur dioxide. The odour, when this substance is impure, is very disagreeable. If taken internally, it produces an intense burning sensation in the throat, headache, and giddiness. In chronic poisoning from the vapour in manufactories where it is used, there appear to be two stages—one of excitement, and one of depression. In the former, there are more or less persistent headache, irritability of temper, tinnitus aurium, and even mania; in the latter, anæsthesia of the skin, even affecting the mucous membranes, patients complaining that their tongues feel as if tied in a cloth. Paralysis of the limbs has been noted in prolonged cases of chronic poisoning. The *post-mortem* appearances do not differ much from those found after death from the inhalation of chloroform. Carbon bisulphide may be separated from organic liquids by distillation, and detected by its odour, and by a black precipitate of sulphide of lead when heated with nitrate of lead and potash.

CHLORAL HYDRATE.

This substance is prepared by acting on alcohol by chlorine. It is used extensively as a hypnotic, and, owing to its indiscriminate use, many fatal cases have been recorded. Care

should be taken when large doses are given not to repeat them too quickly, as there appears to be a tendency to accumulation, and sudden and dangerous action of the drug.

Symptoms.—Chloral, in moderate doses, acts on the brain as a powerful hypnotic, the early symptoms being gradual drowsiness, followed by deep sleep. With a dose of about 30 grains, the patient can, however, by walking about, ward off sleep. In large doses the narcosis becomes completely uncontrollable, and the poison then acts as a depressant to the basal ganglia of the brain, and on the spinal cord; and, as a result, there is weakness of the heart's action, with ultimate diastolic arrest, slowing of the respiratory movements, and general muscular weakness, with some anæsthesia. Under these circumstances the patient has all the appearance of a drunken person, the face is flushed, and the deep sleep may pass imperceptibly into death without any marked change. In some cases delirium precedes the condition of sleep. The pulse in some cases is quickened, and the face flushed; but, in other cases, the pulse becomes slow and almost imperceptible, the heart being ultimately arrested in diastole. In these cases the face is pale, and the breathing performed at long intervals. The motor paralysis present, when a poisonous dose is taken, is due to the action of the drug on the spinal cord, and not on the nerves. During the sleep produced by chloral, the pupils are contracted, but dilate on the person awakening. In a case described by Dr. Levinstein, and reported in the *Lancet*, 21st February 1874, the patient took six drachms with intent to commit suicide. The face was at first flushed, the veins swollen, and the pulse 160 per minute; he then became livid, the pupils contracted, and at times the circulation appeared to be entirely arrested. The temperature varied from 32·9° C. to 38·7° C. (89·6° F., 100·4° F.). This case recovered under treatment by the subcutaneous injections of strychnine (·03 to ·04 grain), and the use of faradisation in thirty-two hours after the poison had been taken. Chronic chloral poisoning, "chloral-drinking," has unfortunately become far too common of late years, in which the mental faculties suffer severely, so that in our asylums, cases of mania and melancholia are rightly (or wrongly) attributed to the habit. A peculiar eruption, not unlike that produced by shell-fish, and followed by desquamation, sometimes occurs when this substance has been given for some time in medicinal doses.

Post-mortem Appearances.—These are not unlike those of asphyxia, the vessels of the brain being engorged, and the ventricles containing an abnormal quantity of fluid. The mucous membrane of the larynx may be injected, and in some cases œdematous. The right side of the heart is engorged and the left empty, together with congestion of the lungs.

Fatal Dose.—The fatal dose cannot be accurately stated, but children, as in the case of belladonna, are said to bear the drug better than adults. A child a year old died in ten hours from a dose of three grains. Ten grains proved fatal to an old lady seventy years of age. Twenty grains has caused death in an adult in half an hour, and in one case thirty grains. As a rule, any quantity over two drachms may be considered a dangerous, if not a fatal dose, although recovery has been stated to have occurred after one ounce. Dr. Richardson considers 120 grains, distributed over twenty-four hours, as a safe dose for an adult. Death may take place suddenly, or after the lapse of several hours.

Fatal Period.—From fifteen minutes, which is the shortest time on record, to thirty-nine and a half hours, which is the longest period recorded.

Chemical Analysis.—Chloral may be extracted from the stomach contents by digestion with absolute alcohol acidified by sulphuric acid. The alcoholic extract is filtered and evaporated. The residue is treated with petroleum ether to remove fatty substances, and finally shaken with pure ether to remove the chloral. On evaporating the ether the chloral hydrate is left. From urine it may be extracted by first acidifying with sulphuric acid and then treating it with petroleum ether and ether. Chloral hydrate in solution gives the following reactions:—

1. On agitation with solution of caustic potash, and gently warmed if necessary, chloroform is evolved, which can be detected by its odour. From a strong solution the chloroform may separate in the form of minute globules.

2. If one drop of ammonium sulphide be added to a solution of chloral hydrate and gently heated, a peculiar opalescent milky reddish-yellow precipitate forms. This test is extremely delicate, and differentiates chloral hydrate from chloroform.

3. Alcoholic solution of potash and aniline when added to chloral hydrate solution, shaken up and warmed, produces the

peculiar odour of phenyl-isocyanide. This is due to the formation of chloroform on the addition of the caustic potash.

4. If β-naphthol dissolved in caustic potash solution be added to a solution of chloral hydrate and the mixture warmed, a blue colour is produced.

5. Chloral hydrate reduces Fehling's solution.

To separate chloroform in the stomach contents from chloral hydrate they should be acidified with tartaric acid and distilled, when the chloroform which was free in the stomach will pass over to the receiver. If the residue be now rendered alkaline with caustic potash and again distilled, any chloroform which then comes over must have been derived from chloral hydrate in the stomach contents.

Treatment.—The treatment consists in washing out the stomach, the administration of emetics, or hypodermic injection of apomorphine, in the use of galvanism, friction, mustard-plasters to the calves of the legs, artificial respiration, and the hypodermic injection of a solution of nitrate of strychnia or injection of atropine. The warmth of the body must be carefully maintained in all cases by suitable external applications. Oxygen inhalations are said to be beneficial.

CHAPTER XIII.

NEURAL POISONS.

CONIUM.

The common or spotted hemlock, *Conium maculatum* (*N. O. Umbelliferæ*), is indigenous. It must be distinguished from the *Myrrhis temulenta*, another indigenous, umbelliferous plant, which has also a spotted stem, but which is covered with hairs—the stem of the hemlock being smooth. Several cases of poisoning have occurred, hemlock having been mistaken for parsley, fennel, asparagus, and parsnip. The leaves of the plant have a peculiar mousy odour, which is intensified when they are rubbed in a mortar with some caustic potash. The poisonous properties reside in an alkaloid, *conine.* The activity of the plant appears to depend upon the time of the year when it is gathered, being most powerful in May. The ready decomposition of the alkaloid by heat or age renders the extract of conium a very uncertain preparation, the conine being converted into an inert resinoid matter.

Conine the alkaloid is a colourless volatile oil, lighter than water, with an odour of mice. It is strongly alkaline, soluble in diluted acid, but its salts have not yet been crystallised. It has been suggested that a ptomaine not unlike conine may be formed in the body by the combination of one molecule of butyric acid and one molecule of ammonia with separation of water, thus—

$$\underset{\text{Butyric Acid.}}{2C_4H_8O_2} + \underset{\text{Ammonia.}}{NH_3} - 2H_2O = \underset{\text{Conine.}}{C_8H_{15}N}$$

Conine is a deadly poison, killing all animals, death resulting from asphyxia. Neutralised with an acid, its activity is increased, and it becomes more soluble in water. Almost instant

death resulted in a dog from injecting two grains of conine, neutralised with hydrochloric acid, into the femoral vein.

Symptoms in Man.—The symptoms in some cases resemble those of poisoning with opium ; in others, the patient complains of dryness and constriction of the throat, and drowsiness. There is dilatation of the pupil, with closure of the eyes or ptosis, and loss of power in the muscles of the extremities, so that the patient falls on attempting to walk. The paralysis does not appear to be due to any direct influence upon the muscles, but upon the motor nerves, and especially on their extreme peripheral ends, and in this differs from Calabar bean, which acts on the spinal cord. Gradual loss of power in the respiratory muscles is the cause of death. Giddiness, coma, and convulsions were the typical symptoms of two cases of accidental poisoning recorded by Dr. Watson.

Symptoms in Animals.—"Palsy, first of the voluntary muscles, next of the chest, lastly of the diaphragm—asphyxia, in short, from paralysis, without insensibility, and with slight occasional twitches only of the limbs; and the heart was always found contracting vigorously for a long time after death" (CHRISTISON).

Post-mortem Appearances.—Congestion of the vessels of the brain and lungs. The blood is very fluid, and of a dark colour, the fluidity due probably to the mode of death—slowly induced asphyxia. There may be some redness of the mucous membrane of the alimentary canal.

Fatal Period.—The symptoms may come on in from ten minutes to an hour, or more, after the poison has been taken. Death usually takes place in about four hours.

Fatal Dose.—Uncertain. Thirty grains of the extract carefully prepared killed a rabbit in five minutes. A single drop of conine dropped into the eye of a rabbit killed it in nine minutes.

Chemical Analysis.—Conine may be extracted from organic mixture by the general process for extracting alkaloids. The following tests may then be applied :—

1. The odour of conine, when diluted with water, resembles that of mice. Harley states that a mixture of caustic potash with organic substances may evolve a similar odour even when conine is absent.

2. On warming conine with sulphuric acid and potassium

bichromate butyric acid is produced, and can be recognised by its peculiar odour.

3. If conine be added to a solution of alloxan a reddish-purple colour is produced in a few minutes, and white needle-shaped crystals form on standing. These crystals if dissolved in caustic potash solution produce a purple colour, and the odour of conine is given off.

Treatment.—Emetics, stomach pump, castor-oil, followed by ammonia and other diffusible stimulants. Artificial respiration should be resorted to and kept up for a long time.

CALABAR BEAN.

A strong emulsion of Calabar bean, *Physostigma venenosum* (*N. O. Leguminosæ*), is used on the West Coast of Africa as a test of innocence in cases of suspected witchcraft. In 1864 some children in Liverpool were poisoned by eating some of these beans, which had been swept out of a ship from Africa on to a heap of rubbish. The poisonous alkaloid is physostigmine or eserine.

Symptoms.—Vomiting, giddiness, irregular action of the heart. The mental faculties are unaffected. The eyes are bright and the pupils *contracted;* in which latter it differs most strikingly from atropine, hyoscyamine, and daturine, where dilatation of the pupil is the rule. The late Sir R. Christison considered that its primary action is on the heart, causing paralysis of that organ, and that the insensibility and coma are only secondary. Dr. Harley considers that it is not a cardiac, but a respiratory poison. Later experiments have shown that the paralysis produced is due to the action of the drug on the spinal cord and not on the nerve trunks. It appears also that death is due to a failure of the respiration, for the heart in animals has been found still beating for one and a half hours after death. The contraction of the pupil, when locally applied, is probably brought about by its paralytic action on the peripheral sympathetic nerve fibres of the iris; and it is stated that when very large doses of physostigmine are given, the pupils dilate, pointing to oculo-motor palsy. A few drops of the extract placed in the eye cause powerful contraction of the pupil.

Fatal Dose.—Six beans produced death in a boy six years of age.

Chemical Analysis.—The alkaloid eserine should be extracted in the usual way, benzene being used as a solvent in the place of chloroform and ether.

Eserine gives the following chemical reactions :—

1. If an aqueous solution of the salt be boiled and then strong nitric acid added, the solution turns a yellowish-orange colour, changed to violet on addition of caustic soda in excess; the violet is discharged on acidulation, but returns on realkalising the solution.

2. A solution of eserine in ammonia solution gives a blue residue on evaporation to dryness. Dilute acids produce a red-coloured solution with it, which is fluorescent by reflected light.

3. Bromine water produces a red turbid solution with eserine, which clears on heating.

4. The physiological test—eserine solution instilled into the eye of an animal produces contraction of the pupil.

Treatment.—The stomach should be emptied and washed out by means of the syphon tube, or emetics administered. One-fiftieth to one-thirtieth of a grain of atropine sulphate should be administered hypodermically and repeated until the pupils dilate. The tincture of belladonna may be given by the mouth. Stimulants should be given and artificial respiration carried out if required.

CHAPTER XIV.

EXCITOMOTORY POISONS.

NUX VOMICA. STRYCHNINE.

Some of the most poisonous known plants belong to the genus *Strychnos* (*N.O. Loganiaceæ*).

The Java poison, Upas Tieuté, is a watery extract of *S. Tieuté*; the basis of the poison used in Guiana, and known as Wourali, Ourari, Urari, or Curare, is the juice of *S. toxifera*. *S. nux vomica*, the Koochla tree, produces the nux vomica seeds of commerce; and the bark of the tree has been accidentally substituted for cusparia, or angustura bark, hence it is known as *false angustura* bark. The substitution is attended with considerable risk, on account of the strychnine which the false bark contains. It may be known by its being quilled, externally covered with white lichenous spots, and the internal surface becoming *blood-red* when touched with nitric acid. This reaction, which depends upon the presence of an alkaloid, brucine, *does not* occur when true angustura bark is thus treated.

NUX VOMICA.

The Seeds of S. Nux Vomica.

The British Pharmacopœia contains an extract and a tincture. The alkaloid strychnine is the active principle of the seeds and other parts of the plant. Another alkaloid, brucine, is also found, and is poisonous.

The symptoms and *post-mortem* appearances and treatment will be detailed under the head of strychnine. The brown powder of the seeds may, in some cases, be seen adhering to the mucous membrane of the stomach.

STRYCHNINE.

Strychnine is very slightly soluble in cold water to the extent of one part in 8300; in boiling water one part dissolves in about 2500. It is more soluble in alcohol, and very soluble in chloroform or ether and chloroform mixed.

It has a bitter taste, so intense, that one part in 70,000 of water can be detected by the taste. Strychnine is not easily

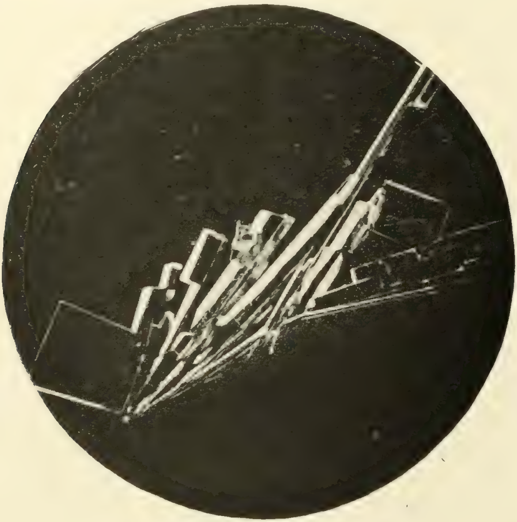


FIG. 35.—Photo-micrograph of crystals of strychnine sulphate from an aqueous solution, ×50. (R. J. M. Buchanan.)

decomposed—it resists the action of warm strong sulphuric acid, and is not altered by putrefactive processes when present in viscera. It has been discovered in the body 322 days after death in one case, 368 days in another.

Allen detected strychnine in the residue of some viscera from a person who had died of strychnine poisoning, and which he had kept in a jar for six years. Richter found the alkaloid at the end of eleven years in putrid tissues which had been exposed to the air all that time in open vessels.

Symptoms.—Should the poison be in solution, the patient

complains of a hot and intensely bitter taste during swallowing. The effects of the poison depending to a great extent on the mode of administration, become manifest in from a few minutes to an hour or more after it is taken. The earliest symptoms are a feeling of suffocation and great difficulty of breathing. These come on suddenly, without any premonitory warnings. Twitching of the muscles rapidly pass into tetanic convul-

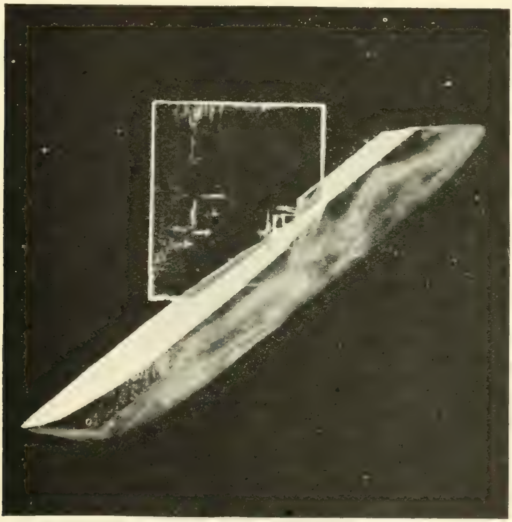


FIG. 36.—Photo-micrograph of crystal of strychnine sulphate from aqueous solution, ×50. (R. J. M. Buchanan.)

sions of nearly all the muscles of the body, which are simultaneously affected. The head after several jerks becomes stiffened; the neck rigid; the body curved forward, quite stiff, and resting on the back of the head and heels. The face is congested, and the countenance expresses intense anxiety; the eyes staring, the mouth open, and the lips livid. The throat is dry, the thirst great; but when an attempt is made to drink, the jaws are spasmodically closed, and a piece of the vessel may be bitten out. During the intervals of the

paroxysms the intellect is usually clear, and the patient appears conscious of his danger, frequently exclaiming, "I shall die!" and he is also conscious of the accession of the paroxysms, telling those around him of their approach, and asking to be held. In the case of J. P. Cook, poisoned by Palmer, those about him tried to raise him, but he was so stiff that they found it impossible. He then said, "Turn me over," which they did, and he died in a few minutes. Intense pain is felt,

FIG. 37.—Photo-micrograph of strychnine sulphate, film preparation from chloroform solution, ×50. (R. J. M. Buchanan.)

due to the powerful contractions of the muscles. After the lapse of a minute or two, the spasms subside, a sudden lull takes place, during which the patient feels exhausted and his skin is bathed in sweat.

In poisoning by strychnine, the jaws are slightly, if at all, affected, trismus is a late symptom, and occurs only during a convulsive seizure.

In tetanus the result of disease, the locking of the jaws is an early and a marked symptom.

As death approaches the fits become more frequent, and the patient dies from exhaustion or suffocation.

Post-mortem Appearances.—There is no characteristic appearance found after death. The blood is fluid, the heart empty, with some congestion of the membranes of the brain. Absence of all cause for so violent and sudden a death. *Rigor mortis* is prolonged for some time.

Fatal Period.—The rapidity in the accession of the symptoms and fatal termination will, to some extent, depend upon the form in which the poison is taken—*i.e.* in solution or in pill. In most cases the symptoms appear in from three or four minutes to an hour or more after the poison is swallowed, death following in from ten minutes to six hours. As a rule, if the person lives for two hours after the onset of symptoms recovery may be expected.

Fatal Dose.—A quarter to half a grain; but large doses have been taken, followed by recovery.

Chemical Analysis.—The poison may fail to be detected, and this link in the scientific evidence may be wanting, as was the case in Palmer's trial. In that case the strychnine had been administered in *pills;* and when after death the stomach had been cut open, and the contents lost, there was little hope of discovering the poison. The non-discovery of the poison was made a strong point on the part of the defence, ignoring at the same time the fact that the stomach had been tampered with and the contents spilt. Death may be the direct result of a dose of strychnine, and yet it may not be detected in the dead body, even with the greatest care, and when the body has not been tampered with. The alkaloid abstracted from the tissues or contents of the stomach by the process generally used for extraction of alkaloids, may have the following tests applied to it:—

1. Scarcely soluble in water, but readily soluble in acidulated water.
2. Intensely bitter taste.
3. Not affected by sulphuric acid; but when a little peroxide of lead, or peroxide of manganese, or bichromate of potash, or ferri-cyanide or permanganate of potassium is added, a magnificent purple-blue colour, changing to crimson, and finally to a light red tint is the result. The $\frac{1}{20000}$ part of a grain of strychnine has been stated to give this reaction.
4. The physiological test consists in introducing a small quantity of the suspected substance under the skin of a frog, and noting whether or not the animal suffers from tetanic spasms.
5. *The Galvanic Test.*—Place a solution of strychnine, say one part of

strychnine in 15,000 of water, in a slight depression in a piece of platinum foil, and allow the mixture to evaporate. When dry, moisten the spot with sulphuric acid, and then connect the foil with the positive pole of a single-cell Grove's battery, and then touch the acid solution with the negative pole. A violet colour will be at once produced, remaining permanent.

6. *Bloxam's Test.*—To the solid alkaloid in a porcelain dish a drop or two of strong nitric acid is added and gently heated ; on adding a small quantity of potassium chlorate a scarlet colour is produced. Ammonia changes this colour to brown and a brown precipitate falls. If the mixture be evaporated to dryness it leaves a dark green residue forming

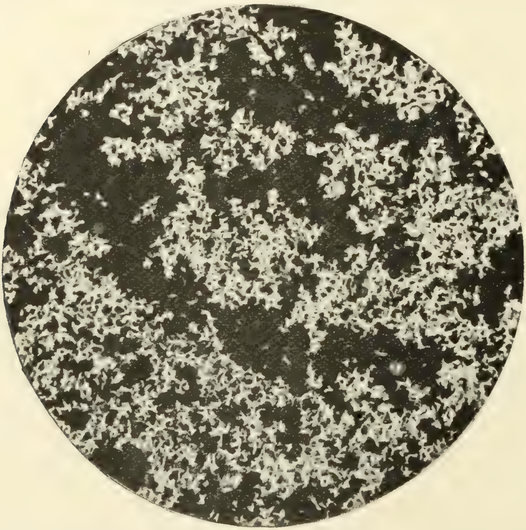


FIG. 38.—Photo-micrograph of chromate of strychnine, ×50. (R. J. M. Buchanan.)

a green solution in water, changed to orange-brown with caustic potash and green again with nitric acid. This test distinguishes strychnine from any of the alkaloids which commonly occur in cases of poisoning.

7. Potassium bichromate when added to a solution of a salt of strychnine, produces a yellow crystalline precipitate of chromate of strychnine : the reaction can be done on a microscope slide and the crystals examined. On drying the crystals and then touching them with a drop of strong sulphuric acid, the purple colour changing through red to green is produced.

8. Picric acid gives a yellow crystalline precipitate of the picrate.

9. Ammonium or potassium sulphocyanate produces crystalline precipitates.

10. Ferricyanide of potassium produces a crystalline precipitate with solutions of salts of strychnine.

Strychnine may not be found in the body, even after death from poisoning by it, for the following reasons :—

1. Smallness of the quantity taken.
2. The time which has elapsed after taking the strychnine until the symptoms commence.
3. If the careful preservation of the stomach and its contents has been overlooked.
4. The alkaloid may have been eliminated from the body before death.

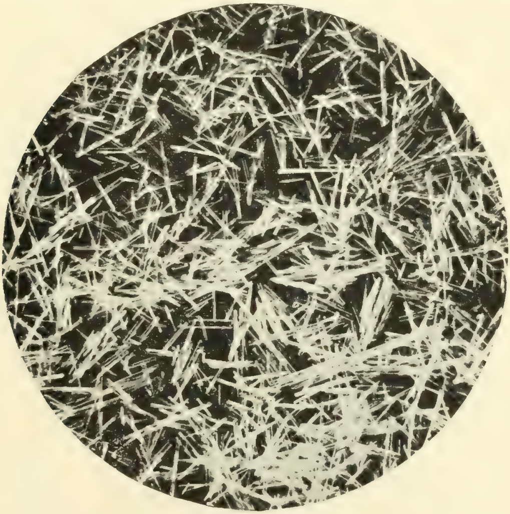


FIG. 39.—Photo-micrograph of sulphocyanate of strychnine, ×50. (R. J. M. Buchanan.)

Treatment.—Evacuation of the stomach by emetics and the stomach pump, and then the administration of animal charcoal, iodide of potash, tannic acid, and tea; bromide of potassium in large doses (half-an-ounce), and repeated in smaller doses. Chloral should be given in five-grain doses hypodermically every ten minutes, until the convulsions are subdued. Chloroform should be inhaled for some time. Urethan is said by Anrep to be more useful than chloral, and should be given in drachm doses.

Differential Diagnosis of Strychnine Poisoning from Tetanus, Hysteria, Epilepsy, and other Poisons causing Tetanic Spasms.

Tetanus.	Tetanus from Strychnine.	Hysteria.	Epilepsy.	Tetanus occurring during the Action of other Poisons.
1. The presence of a wound. Symptoms have no connection with any liquid or solid swallowed.	1. Some solid or liquid taken within a short time of commencement of symptoms. Not connected with any peculiarity of constitution.	1. Connected with a peculiar constitution. Rare in males.	1. Previous history of epilepsy.	1. The presence of other symptoms of poisoning peculiar to certain poisons.
2. Gradual accession and progress of the symptoms; difficulty in swallowing; stiffness of the jaws, neck, trunk, legs, and arms. The hands not generally affected.	2. Symptoms sudden and violent. All the muscles are affected at one and the same time. Arms affected and hands clenched at the same time as the body and legs. Jaw only affected or fixed during efforts to swallow.	2. The presence of known signs of hysteria.	2. Presence of the *aura epileptica*. The tongue bitten; and insensibility lasting for some time.	*Obs.*—Arsenic, antimony, and other irritant poisons may sometimes cause tetanic spasms; but other symptoms are present which point to the nature of the poison.
3. Curving of the spine forwards not primarily present; generally comes on after some days of previous illness.	3. Opisthotonos an early symptom, generally appearing in a few minutes.	3. The spasms frequently convulsive, and alternating with stiffness of the muscles. Loss of consciousness.	3. Alternate contraction and relaxation of the muscles.	
4. Symptoms may undergo abatement, but there is no perfect intermission.	4. Intervals of complete intermission.	..	..	..
5. Death after the lapse of several hours or days. Direct injury to spinal cord may give rise to tetanus and death in a few hours. Recovery slow.	5. Death usually occurs in two hours, or even less than a quarter of an hour. Recovery in a few hours.	5. Never fatal. Recovery very rapid.	5. Seldom fatal during first attack.	..

BRUCINE.

This alkaloid is present along with strychnine in Nux Vomica seeds and the Ignatius bean. Cases of poisoning by it seldom occur, as the alkaloid is but little known by the public.

Symptoms.—It resembles strychnine in its action but is much less poisonous. It produces death by convulsions when injected subcutaneously, but according to Brunton does not so often produce convulsions when taken into the stomach.

FIG. 40.—Photo-micrograph of crystals of brucine sulphate, ×50. (R. J. M. Buchanan.)

Chemical Analysis.—The alkaloid may be extracted from organic admixture by the usual methods. Its reactions to special tests are as follows :—

1. If nitric acid be added to the solid alkaloid, or in aqueous solution, a bright red colour is produced which changes to yellow on heating. The addition of stannous chloride or sulphide of ammonium to the acid solution changes it to violet ; the colour is discharged by excess of the stannous chloride. If the red acid solution be largely diluted with water, a yellow

precipitate falls, soluble in dilute hydrochloric acid. If the filtrate from the yellow precipitate be neutralised by ammonia and calcium chloride added, a precipitate of calcium oxalate forms, insoluble in acetic but soluble in hydrochloric acid. This reaction is peculiar to brucine.

FIG. 41.—Photo-micrograph of crystals of brucine sulphate, ×50. (R. J. M. Buchanan.)

2. With sulphuric acid and potassium bichromate a deep orange-red colour is produced.

3. Sulphomolybdic acid gives an orange-red or purplish-red colour, changing to blue.

4. *Blyth's Test.*—If methyl iodide be added to a solution of brucine in strong alcohol, circular rosettes of crystals form in a few minutes. Strychnine does not give this reaction.

Treatment.—Same as for strychnine.

CHAPTER XV.

IRRESPIRABLE GASES.

CARBONIC ACID GAS.

Circumstances which may show that it is suicidal.—The position of the body and the presence of one or more of the methods adopted for the generation and escape of the gas. But it must always be borne in mind that, in order to conceal a murder, the body may be placed under circumstances which point to carbonic acid poisoning. Poisoning by this gas is a favourite mode of suicide in Paris.

Circumstances under which it occurs accidentally.—Death may result where several persons are sleeping in the same room, and the ventilation is imperfect; from the admission of the vapour of charcoal into a room from an adjoining vent; or from incautiously sleeping in a brewery close to a vat in which fermentation is going on. Many deaths have occurred from this gas, due to the incautious descent into wells. It must also be borne in mind that death may result from the presence of this gas in an atmosphere which will permit the combustion of a candle. For a candle will burn in an atmosphere containing 25 per cent of CO_2, whereas 5 per cent will cause death. The burning of a candle is therefore no test of security from danger in an atmosphere where the presence of carbonic acid is suspected. Carbonic acid does not, as is generally supposed, sink to the lower portions of a room; and Dr. Taylor, from his experiments, states "that in a small and close room persons are liable to be suffocated at all levels, from the very equal and rapid diffusion of carbonic acid during combustion."

Symptoms.—When the carbonic acid is pure, that is,

unmixed with other gases, spasm of the glottis at once occurs, and the sufferer falls down insensible, and death is almost immediate. When the gas is diluted the early symptoms are a feeling of weight and fulness in the head, accompanied with giddiness, throbbing of the temporal arteries, drowsiness, palpitation of the heart, gradually increasing insensibility, stertorous breathing, ending in death from asphyxia or apoplexy. Sometimes the victim dies convulsed, at other times a deep sleep quietly merges into death. The symptoms will, of course, depend upon the quantity and purity of the gas present in the apartment.

Action on the Animal Economy.—The opinions of observers vary greatly—Berzelius maintaining that an atmosphere containing 5 per cent was not injurious to life; Allen and Pepys, on the other hand, stating that 10 per cent of the gas would cause death. Bernard considers that it is not poisonous, as it can be injected into the bodies of animals without injury, and that its action is purely negative; it is irrespirable in the same sense as pure hydrogen or nitrogen is—simply, therefore, causing death by suffocation. Whatever may be the true explanation of its action, it is enough for all practical purposes to know that death follows when it is breathed, even when mixed with a normal amount of oxygen.

Post-mortem Appearances.—The face may be pale and composed, or swollen and livid. The vessels of the brain are frequently greatly congested, and the heart and great vessels gorged with black fluid blood. The blood in some cases, however, is of a cherry-red colour. This may probably be due to the presence of carbonic oxide, which appears to have the power of preventing the change of arterial into venous blood, the opposite effect to that of carbonic acid. The tongue may or may not be protruded beyond the teeth; in most instances the latter is the case. Animal heat is long retained after death, and the *rigor mortis* occurs as in other forms of death.

Treatment.—Bleeding from the arm, cupping from the nape of the neck, and the employment of cold affusion to the head. The patient should be removed without delay into the open air. Artificial respiration and galvanism have been successfully employed in some cases, and inhalations of oxygen should be used if possible.

How the proportion of Carbonic Acid may be estimated.—The air to be examined is drawn into a vessel capable of holding one and a half gallons, to which is added a clear solution of lime or baryta. The vessel, after being well agitated, is allowed to remain untouched for from eight to twenty-four hours. The carbonic acid is absorbed by the lime or baryta, and the difference in the causticity of the lime solution before and after it is placed in the vessel gives the amount of carbonic acid present in the air. A simple method of collecting the air in a mine is by lowering a bottle full of fine sand, so arranged that at any depth it may be turned upside down, and the sand allowed to run out, its place being taken by the air of the mine. The bottle may now be quickly drawn up, corked, and reserved for examination.

How may an Apartment, a Well, or Mine be cleared of it?—Free ventilation in the first case. In the case of a well, a basket of slaked lime may be let down; but in mines a steam fanner or a jet of steam must be blown through the mine. No one, of course, should be allowed to enter the well or mine until it has been cleared of the carbonic acid.

CARBON MONOXIDE.

This gas is formed in a variety of ways, one being the oxidation of carbon at a very high temperature in a limited supply of oxygen. It is given off by iron stoves at a red heat. It is one of the chief ingredients of the vapour of burning charcoal.

To this gas is due the suffocating quality of air in which coke or charcoal is burnt. It is inodorous, hence the dangerous insidiousness with which it produces its fatal results. It is said that ·5 per cent will cause death, and even ·1 per cent is injurious. The vapours from brick kilns and "burnt ballast" heaps are injurious to health, and the owners of them may be indicted for causing a nuisance.

The fumes from burning charcoal are taken advantage of for purposes of suicide, a method frequently used on the Continent, but almost unheard of in England. The suicide generally shuts himself up in a room, which he has closed against any ventilation, and in which he has placed a receptacle containing burning coke or charcoal.

Poisoning by carbon monoxide occurs in two forms—*acute* and *chronic.*

Symptoms: Acute.—The first symptoms may be those of excitation, which are quickly followed by intense headache, giddiness, throbbing of the temples, and nausea followed by vomiting. Muscular weakness occurs, sensation and the reflexes are lost, drowsiness and coma follow, and in fatal cases convulsions often come on before death. The pulse becomes imperceptible at the wrist. The conjunctivæ become hyperæmic, the eyes staring, the pupils dilated and insensible. The voluntary and involuntary muscles are relaxed, the skin cold and cyanotic, and the lips covered with froth.

Chronic.—The symptoms are headache, neuralgic pains, anæmia, shortness of breath, and wasting; when advanced they are those of peripheral neuritis and mental disturbances.

The less severe symptoms of chronic carbon monoxide poisoning are not uncommon, and occur in those who occupy small and badly ventilated rooms, in which there may be a heating stove, gas stove, or imperfect gas fittings; the last are especially dangerous when water gas is used for illuminating purposes, as it contains a high percentage of carbon monoxide.

It is a very powerful gas, speedily causing death by acting chiefly on the nervous system, the symptoms being those produced by a pure narcotic.

The *post-mortem* signs are redness of the face, with reddish patches on different parts of the body. The blood—and this is chiefly characteristic of carbon monoxide poisoning—is cherry-red, due to a chemical compound formed by the action of the gas on the colouring matter of the blood, thus paralysing the oxygen-carrying power of the blood corpuscles. The gas is supposed to combine with the hæmoglobin forming a fixed compound, the spectroscopic examination showing the two absorption bands of the hæmoglobin nearer to the violet end of the spectrum than under normal conditions. (See Blood Spectra, p. 112.)

These bands resemble those of O_2Hb, so their position must be compared with a spectrum of O_2Hb, the two spectra being side by side.

There is another important difference, however, determined by the action of a reducing agent such as ammonium sulphide. The bands of COHb are unaltered, while the O_2Hb is reduced.

Death frequently takes place before all the Hb has been changed into COHb, so that the blood contains a mixture of COHb and O_2Hb, and on the addition of a reducing agent the spectrum is a composite one of COHb and reduced Hb. Only the broad band of reduced HB is to be seen if the amount of COHb present be less than 28 per cent. In an atmosphere containing a large percentage of carbon monoxide death may occur before the blood contains sufficient COHb to give the characteristic spectrum.

The *treatment* consists in the removal of the sufferer into the fresh air, artificial respiration, venesection, and the transfusion of arterialised defibrinated blood. Oxygen inhalations should be given. In two cases subcutaneous injections of nitro-glycerine were followed by recovery.

WATER GAS.

This gas is prepared by passing steam through incandescent carbon, and is a compound of nearly equal parts of carbonic oxide and hydrogen. It owes its dangerous properties to the first-named gas. When water gas, pure and simple, is supplied for heating purposes, its leakage cannot be detected, as the gas possesses no odour. When used for lighting and carburetted, its escape is more readily detected by the smell, but even then it is more dangerous than coal gas as the proportion of CO is higher. Several deaths have resulted from the use of water gas for heating and lighting purposes, and also for steel smelting in Leeds. The symptoms of poisoning are those of carbonic oxide.

SULPHURETTED HYDROGEN.

Sulphuretted hydrogen is a gas possessing a powerful odour of rotten eggs. It is largely used as a test for most of the metals; and its presence may be detected by filter paper, moistened with a salt of lead, becoming black.

Symptoms.—When the gas is moderately diluted the symptoms produced are giddiness, throbbing of the temples, pain and oppression of the stomach, nausea, and vomiting; delirium and convulsions sometimes occur, together with laborious respiration and an irregular pulse. When the gas is

but slightly diluted, the person becomes suddenly weak and insensible, and rapidly dies.

Post-mortem Appearances.—Fluidity and blackness of the blood, loss of muscular contractility, and a tendency to rapid putrefaction. The bronchial tubes are reddened, and the internal vascular organs may appear almost black.

Treatment.—This will consist in the immediate removal of the person into fresh air, and the administration of stimulants, together with the respiration of chlorine gas evolved from bleaching powder by the action of an acid.

COAL GAS.

Coal gas is composed of several hydrocarbons, the chief of which is marsh gas, together with free hydrogen, carbonic oxide and carbonic acid, ammonia, hydrogen sulphide, and sulphides of carbon, which give to it its peculiar odour. The poisonous properties of coal gas are due to the carbonic oxide, 7·5 per cent being present in ordinary gas as supplied for illuminating purposes. It can be detected by passing the coal gas through an acid solution of cuprous chloride, which becomes black by the formation of a compound CuCOCl. A dangerous explosive compound is formed when the gas reaches the proportion of 1 in 10 of the atmosphere. Poisoning by this gas is, as a rule, accidental.

Symptoms.—Headache, nausea, vomiting, giddiness, ending in coma. Stertorous breathing is noticed in some cases. Should the sufferer be removed from the gas, the breath smells strongly of the gas. The murderer Chantrelle tried to cover his crime by admitting gas into his wife's bedroom, but the attempt failed. The pupils are, as a rule, dilated before death.

Post-mortem Appearances.—Cherry-red colour of the blood, redness of the pulmonary tissue, and froth in the air passages. The vessels of the brain are engorged, and rose-coloured patches appear on the thighs.

Treatment.—This consists in removing the patient into the fresh air, artificial respiration, etc.

SECTION III.

PUBLIC HEALTH.

CHAPTER I.

SITE AND SOIL.

SITE.

Under ordinary circumstances in this country, especially in the neighbourhood of towns, the selection of the site is limited by considerations of cost and convenience. It is evident from the experiences of large towns extending over wide areas, in which there are great differences in the composition of the subsoil, that if the requirements of sanitation are observed the inhabitants are equally healthy whether the subsoil of the locality be clay, sandstone, or rock; there may be differences in the case of large rural districts in which one soil largely predominates which are not appreciable in urban localities, but objectionable features can often be removed if sufficient care be exercised in dealing with them. If water can be drained away readily, the supposed disadvantages of clay can be minimised or altogether removed, and a house on a clay soil is not necessarily more open to objection than one on gravel. Indeed, porous soils are far more liable to organic pollution and the dangers resulting from it than clay, and clay is preferable to such a porous soil.

Every site selected for building purposes must be wholesome; in the suburbs or outlying districts of growing towns dangers associated with "made" land may arise, *i.e.* land which has been levelled by filling up hollows and depressions with organic refuse. No dwelling should be erected upon

ground which has been impregnated with animal or vegetable refuse until the lapse of a sufficient number of years to render the material innocuous. If good material, *e.g.* clean soil, has been used to fill up hollows, these objections do not hold. Sites where the circulation of air and access of sunlight are interfered with, whether from their low situation or because they are shut in by trees or lofty buildings, should be avoided as unhealthy. In this country a maximum of sunshine should be aimed at, and a house facing S.E. and rear N.W. would secure this.

Sites in low situations, excavations, or below the level of plains may be damp, and consequently unwholesome, from surrounding subsoil drainage.

SOIL.

Soils exercise their important influence upon buildings chiefly by the readiness with which moisture (dampness) or impurities may be brought into them. It must be remembered also that it is not merely that portion of the site actually covered by occupied rooms which is important, but under certain circumstances the occupants may be affected by conditions of subsoil which exist at considerable distances. All soils, except perhaps the hardest rocks, are more or less porous, containing innumerable interstices comparable to those of a hard, close sponge; these are filled either with "ground" air—which differs widely in its composition from ordinary atmospheric air—or with "ground" water, which also may be widely different from pure water, and may in fact bring dangerous impurities from a distance. The interstices of the soil are occupied alternately and for varying periods either with ground air or ground water; as the water recedes in dry weather it will leave behind it some at least of any impurities which may have been dissolved or suspended in it, and these, by their decomposition, modify the nature of the air in the soil, *i.e.* the "ground" air.

The air in soils differs from atmospheric air in important particulars. The amount of carbonic acid gas is in excess, the amount increasing with the depth of the strata from which the soil air is taken; at the same time the amount of oxygen is diminished. Soil air, again, is usually very moist; it may also contain organic constituents from the decay of animal and

vegetable substances. Rainfall and warmth exercise an important effect upon the composition of soil air, as well as upon its movement; variations in volume by change of temperature give rise to continual movement, and the rise of the ground water, consequent upon rain, will slowly force out the soil air. It is not difficult to understand that occupied buildings, artificially warmed in winter, and almost always warmer than the ground which surrounds the sites upon which they stand, must, unless means be taken to prevent it, be continually drawing in ground air not only from below, but also laterally. When the surrounding surface is impervious, or rendered so by paving or frost, this is especially likely to happen. In this way leakages, *e.g.* of coal gas, may pass from long distances into occupied buildings, and noxious oozings and emanations from defective cesspools and middens, or from accumulations of manure, etc., may also be causes of mischief to premises at a distance. It is especially obvious that dwellings built on "made" land may be rendered unhealthy so long as the constituents of the foundation contain decomposing impurities, since the impure ground air may ascend into the rooms.

Water, instead of air, may occupy the interstices of soil, and may be derivable from rain, or from percolation and capillarity from subterranean water, pressure from rising of adjacent rivers, etc.

The capability of soils for absorbing and retaining water varies very considerably; almost all soils will take up some, loose sand may absorb as much as two gallons in a cubic foot, sandstone about one gallon, chalk takes up about 15 per cent, clay 20 per cent, and is very retentive of it. The distinction must be borne in mind between a soil which is merely permeable, *i.e.* one which takes up water readily, allowing it to percolate through, and which quickly dries, and an absorptive soil, retentive of moisture, permeable only to a very limited extent, and remaining wet. Sandstones illustrate the first case, clay the second; rock is almost impervious, and absorbs practically no water.

The rise and fall of ground water is indicated by the rise and fall of water in wells, but careful observation is necessary in order to ensure correctness in conclusions.

It will be evident that when soils are damp from any cause, a non-retentive permeable soil can be more easily made dry by

subsoil drainage than one which does not admit of ready percolation.

The degree of moisture in clays varies considerably; clays are less likely to allow the passage of gases through them than porous soils.

Special drains to take off ground water are frequently laid by the side of sewers.

It is, however, the nature of the soil of the immediate locality that is of importance in the influence which it is likely to have upon the health of the occupiers of buildings. The rocks, slates, chalk, gravel, sandstones, are usually healthy and dry, unless in the latter case clay underlies a superficial sand-rock or sandy soil, when dampness may be found. Wet clays and alluvial soils are frequently associated with dampness, and require to be carefully dealt with.

It should always be borne in mind that a house, having a higher temperature than the surrounding air, acts as an exhauster of the soil beneath, and this is shown by the smell of gas present in a house not supplied with gas, the presence of the smell being the result of permeation through the soil of gas from a neighbouring broken gas-pipe. The effluvia from cesspools or drains may be thus drawn into a house, especially if the soil be loose or gravelly; and this may occur even in severe winters, with the ground frozen solid for some feet below the surface. The presence and amount of water in the soil also demands attention, and necessitates a good system of subsoil drainage. The observations of Pettenkofer on the wells of Munich suggested to Buhl the probable relationship between the height of the ground water and epidemics of fatal typhoid fever, the outbreaks occurring when the ground water was lowest, but especially when it had reached an unusual height, and had then rapidly subsided.

It can easily be seen that when the ground water sinks, air is drawn into the soil; and that when the ground water rises, it is forced out more or less impregnated with foul gases.

The height of water in a well may be taken as a good guide as to the amount of the subsoil water.

Deep drainage, and opening the outflow, are the only means to get rid of the excess of the subsoil water. While advocating a perfect system of subsoil drainage, Mr. Denton lays great stress on the necessity of keeping the drainage of the soil

distinct from the sewerage, "inasmuch as the same apertures which let the water from the subsoil into the sewer will let the sewage out of the sewer into the subsoil whenever the pressure from within is greater than that from without; and we must also remember that whenever sewage itself escapes sewer gas will escape too."

Air in the Soil.—The amount varies with the nature of the soil—probably from 40 to 50 per cent in loose sands or gravel —and is being constantly changed. The amount of carbonic acid probably owes its origin to organic processes going on in the soil. To test the air in the soil of any given locality, a long iron tube with a pointed solid end, but with small holes near its extremity, is driven into the ground to the required depth, and an aspirator attached to the free end, when air can be drawn from the soil and examined. Owing to bad drainage and the presence of decaying animal and vegetable matter in the soil, the contained air may become impregnated with sulphuretted hydrogen, ammonium sulphide, carburetted hydrogen, etc. "It appears manifest to me that the escape of these constituents into the ground surrounding dwellings must be injurious, for the gases evolved in sewers are frequently fired by the candles of sewer men; and in a case in my own practice, where an examination was being made of the condition of a sewer running *under* a large establishment, in which there were at the time 250 inmates, the confined gas took fire from a workman's candle, and passed through the entire length of a long basement. Little attention is at present given to matters like this, though they cannot fail to show that sewers with air-tight joints are desirable near dwellings. If they are air-tight they are necessarily water-tight, and then the sewage itself, with its 72 parts of dissolved solids in 100,000 parts, will not escape into the soil surrounding the sewer, to render it 'excrement sodden,' and gravitate by soakage to the foundations and basements" (J. B. Denton.)

Air in Soil is estimated as follows:—In the case of rocks, first, after careful drying, determine specific gravity, and then weigh before and after submersion in water. Thus—

$$\frac{\text{Weight of water taken up} \times 100}{\text{Weight of dry rock} \div \text{specific gravity}} = \text{percentage of air.}$$

In the case of loose soil, dry soil at 100° C. (212° F.),

reduce to coarse powder and place it in a burette, gently tapping it to expel as much air as possible. Take another burette, and connect by india-rubber tube the bottom of it to the first, taking care to have a stop-cock between them. Into No. 2 pour some water; then open the stop-cock, and allow some water to rise gradually through the soil in No. 1, so that the water stands just above the soil. Read off from No. 2 the quantity passed through to No. 1, and calculate as follows:—

$$\frac{\text{Amount of water used} \times 100}{\text{Cubic centimetres of dry soil}} = \text{percentage of air.}$$

Ground Water.—Soil partly filled with air and water is said to be *damp;* but when all the air is expelled by the water, the degree of humidity thus reached is called *ground water.* It commences at the lowest limit of the air in the soil. The ground water is due partly to rain, and partly also to the rising by capillary attraction of the water flowing on the surface of the more impermeable rocks. Two gallons of water may be contained in a cubic foot of loose sand, and one in the same bulk of ordinary sandstone.

Ground water is measured by taking the depth of the water in the wells in the neighbourhood. This may be done by attaching a series of cups at equal distances along a rope, and carefully letting the rope down; the last cup filled will nearly give the depth of the water. A wooden rod is better than a rope, as the latter has a tendency to stretch. The amount of moisture in the soil may be determined by drying a weighed quantity at a temperature of 220° F., and noting the loss of weight; or the soil may be dried, weighed, and then exposed to the air: the increase of weight will give the amount of moisture taken up.

SOIL IN RELATION TO DISEASE.

Certain forms of disease are well known to be associated with impurity or dampness of soil. Micro-organisms abound in soils. The vast majority, no doubt, are beneficent, but some pathogenic organisms live and multiply in the earth, *e.g.* the bacilli of tetanus or anthrax, while diseases such as enteric fever, diarrhœa, cholera, and yellow fever are closely associated with defined conditions of soil.

Anthrax bacilli have been found in soils infected by the blood, discharges, or carcases of infected animals, and cattle pastured upon areas so infected have acquired the disease. Hence the carcases of diseased animals, if buried, should be put well below the surface.

The prevalence of cholera and enteric fever has in some districts been very definitely associated with the rise and fall of ground water, the sudden fall from an unusually high level being frequently followed by increased prevalence of typhoid.

Pettenkofer considers the following conditions to be necessary for the production of typhoid fever :—

1. Unusual height of ground water followed by a rapid sinking.
2. Impurity of the soil from animal impregnation.
3. Heat of the soil.
4. Presence of a specific germ.

Diarrhœa occurring amongst infants and adults during the summer and autumn months has a close connection with filth-sodden soil.

The association of malaria with swamps, marshes, and pools is very close ; these are the breeding-places of the species of mosquito (*Anopheles*) known to be the medium of conveyance of the malarial organism. One of the effects of draining and drying the soils of malarial districts is to destroy the breeding-places of the mosquito.

Phthisis, catarrhal conditions, rheumatism, are commonly predisposed to by damp cold sites ; a lessening of the prevalence of pulmonary disease has followed upon drying the soil by drainage, as shown by Bowditch and Buchanan.

CHAPTER II.

CONSTRUCTION AND SANITATION OF BUILDINGS.

It is not often that towns offer much choice of soil—whatever geological condition is present has to be accepted and dealt with. Soils are usually tabulated in order of healthiness, following the table of Dr. Parkes :—

1. Primitive rock, clay slate, millstone grit.
2. Gravel and loose sands with permeable subsoils.
3. Sandstones.
4. Limestones.
5. Sands with impermeable subsoil.
6. Clays, marls, alluvial soils.
7. Marshes.
8. Filled-up ground.

If water can be drained away readily, the supposed disadvantages of clay can be minimised, or altogether removed, and a house on a clay soil is not necessarily more open to objection than one on gravel. Indeed, porous soils are far more liable to organise pollution and to the dangers resulting from it than clay, and clay is preferable to such a porous soil.

The under-draining of damp sites is important.

The use of proper concrete in dealing with building sites that are at all doubtful is imperative if healthiness is to be secured.

FOUNDATIONS AND BASEMENTS.

Basements are often very troublesome to keep dry.

Adequate foundation should be secured for all walls—where the ground is not sufficiently good, concrete foundations should be formed, on which to commence the footings of brick walls.

The use of the dry area is valuable round basements.

In order to exclude the possibility of damp, as well as to keep

out ground air, it is necessary to completely cover the whole of the site with concrete, or some material equally close and hard. The character of the material used is of the utmost importance; only the best concrete which can be obtained should be employed; the inferior kinds met with contain too little lime or cement, and crumble away, leaving interstices into which air will pass or water will creep by capillarity, not only making the

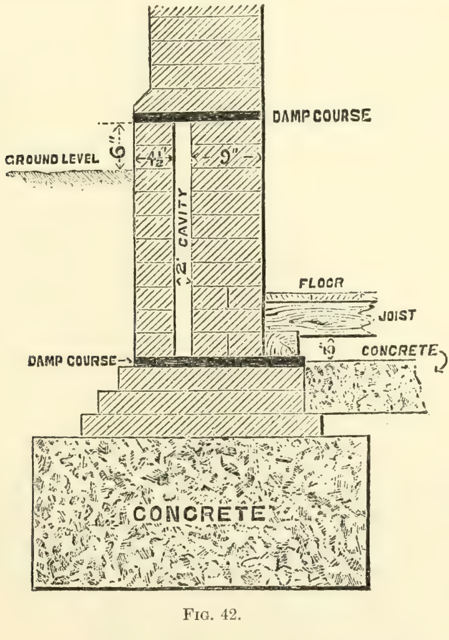


FIG. 42.

house unwholesome, but possibly endangering the structure. The necessity for careful attention to these precautions is obvious. In the absence of some special foundation, danger may arise not only from gases immediately beneath the building finding their way into it, but—especially in times of frost—they may be drawn from considerable distances beneath the hard frozen surface of the ground. The thickness of the cement concrete should be from 4 to 6 inches.

In many instances this concrete may serve as a floor itself; in passages, halls, out-buildings, this would be the case. When a boarded floor is necessary a space should be left for ventilation between the concrete and that floor. This measure serves

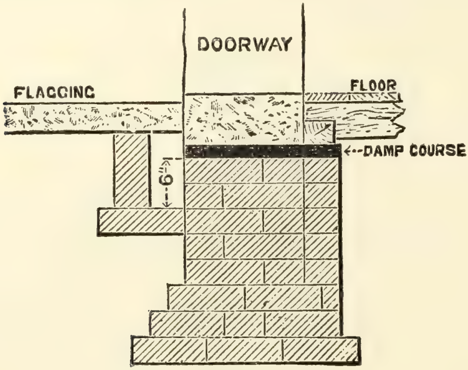


FIG. 43.

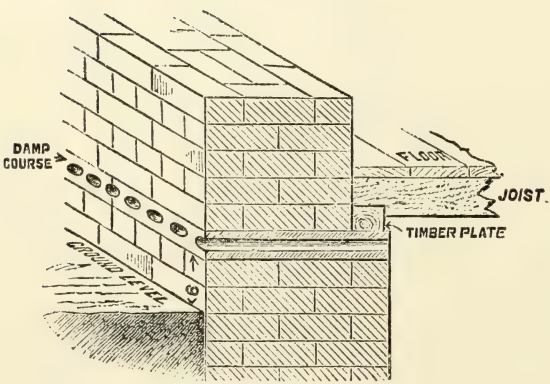


FIG. 44.

as a valuable precaution against dry rot, and a clear and continuous space of at least 3 inches between the under side of every joist of such floor and the general surface of the asphalte or concrete with which the ground beneath may have been

covered, should be allowed. The ventilation of this space can be ensured by means of air-bricks (Figs. 42 and 44).

Special care must also be taken to protect the part of the walls which is situated below the level of the ground, and with a view to render them impervious to damp, exceptionally good material should be used, and a damp-proof course provided in the wall all round the building, or this part of the external wall may be constructed with a cavity 2 or 3 inches wide between the external and internal faces of the wall, the two portions being joined by bonding ties of suitable material of a non-absorbent character (Fig. 42).

In order to prevent the passage of moisture up the walls of the building, a damp-proof course must be laid completely across the wall, and extending all around the building. This damp-proof course should be laid a little distance, say a few inches, above the ground level, and it should be employed in all cases, whether the site be a damp one or not. It may consist of asphalte, slate cement, or pitch, or slate in cement, or other material. Sometimes a sunk area may be necessary, in order that any mound of earth rising higher than the damp-proof course may be kept away from the wall. In this way the building would either have an open area above the damp-proof course or a specially constructed dry area.

Questions of solidity, foundations, proper width of footings, solidity and thickness of walls, etc., fall within the province of the architect and the builder.

Whenever the dampness of the site renders such a precaution necessary, the subsoil should be drained by means of suitable earthenware field pipes, properly laid to a suitable outfall.

Whilst such careful precaution is necessary to protect the building from damp from below, it is equally necessary to guard against dampness from rain falling upon the roof; suitable gutters and downspouts must therefore be provided to carry off such water, and these downspouts must not pass down direct into the drain, but terminate over suitable trapped gullies, in the manner subsequently described.

DRAINAGE AND SEWERAGE.

Some of the salient points in connection with the drainage must be considered in a little more detail. The "house drain" or "private communicating sewer" between the soil pipe and

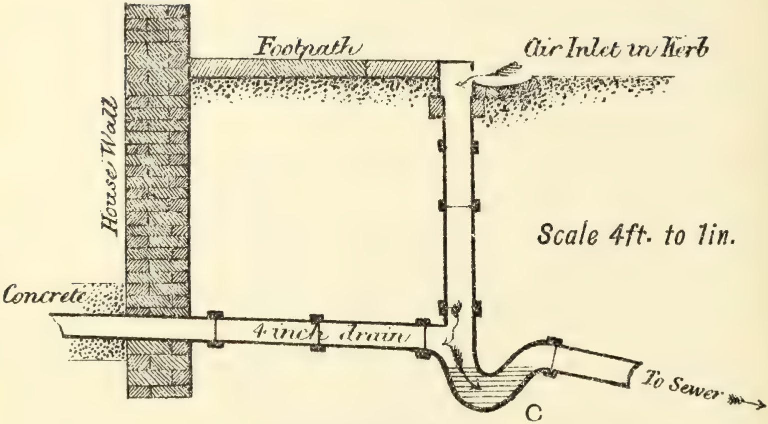


FIG. 45.—GENERAL SECTION.
Main drain disconnecting trap with air inlet in kerb of street footpath.

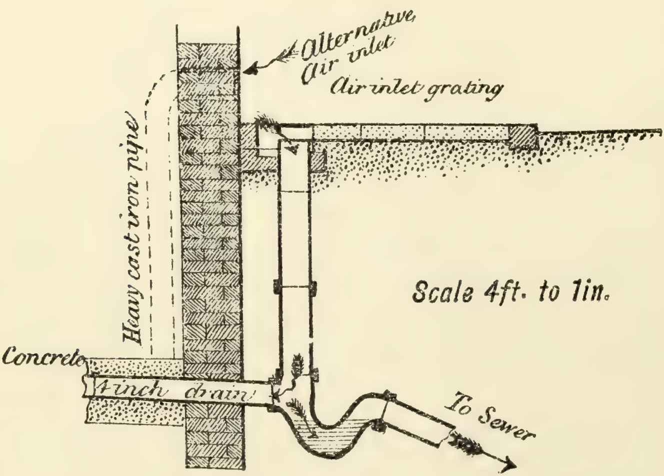


FIG. 46.—GENERAL SECTION.
Detail of main drain disconnecting trap with air inlet in street footpath.

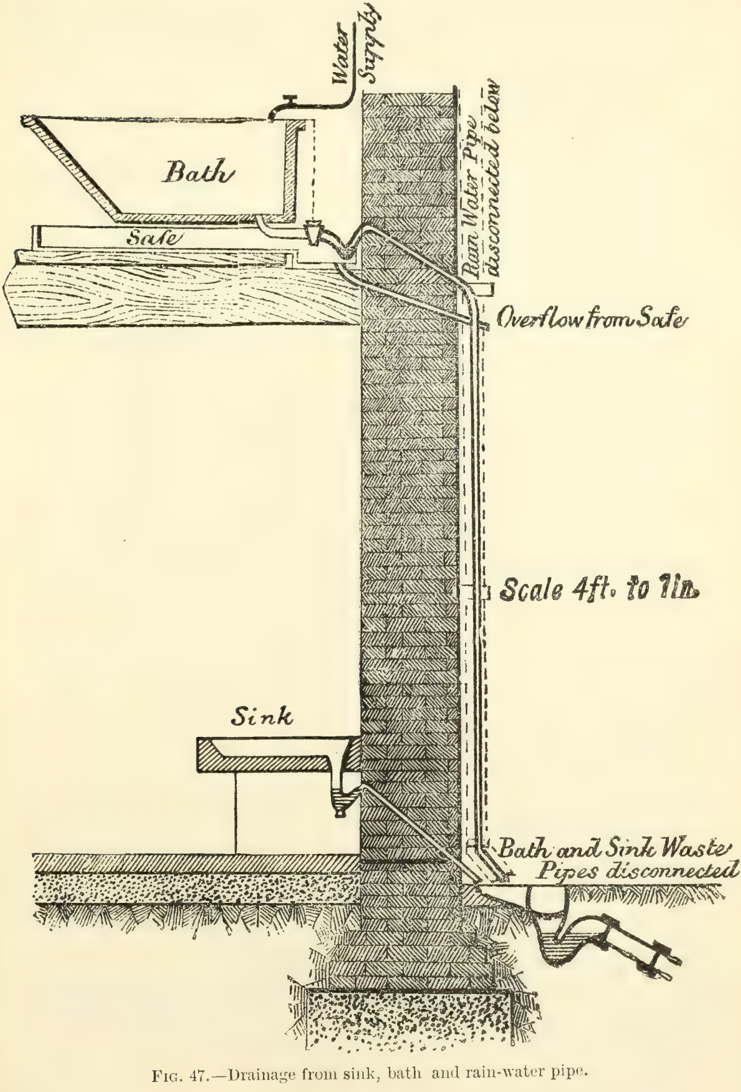


FIG. 47.—Drainage from sink, bath and rain-water pipe.

the main sewer should be constructed of stoneware glazed pipes, jointed in such a manner as to be absolutely water-tight. It should in no case pass under any part of the building, unless this cannot be avoided. It should then, in that part of its course, be bedded in concrete at least 6 inches thick all round, and provided with means of inspection at either end. A recess should be cut in the bed of the drain-pipe trench for the socket of the pipe, and then cement should be used for the packing. Every pipe should be wiped out as laid.

The whole course of this "private connecting sewer" or "house drain" should be in a straight line, or as direct as possible: if one line cannot be adopted, there should be straight lines from angle to angle with an inspection shaft at each angle. It should be laid at such an inclination as will secure a velocity of not less than 3 feet per second, and the diameter should be 4 or 6 inches, in accordance with the number of lavatories discharging into it. A disconnecting trap with a fresh air inlet on the house side of it, should be placed upon the house drain at a convenient place near to the common sewer.

The soil pipe should be 4 inches in diameter, and left open at the top, which should be carried to a safe place above the eaves without any lessening in the diameter. Sometimes a wire cage is placed over the soil pipe to prevent birds building in it.

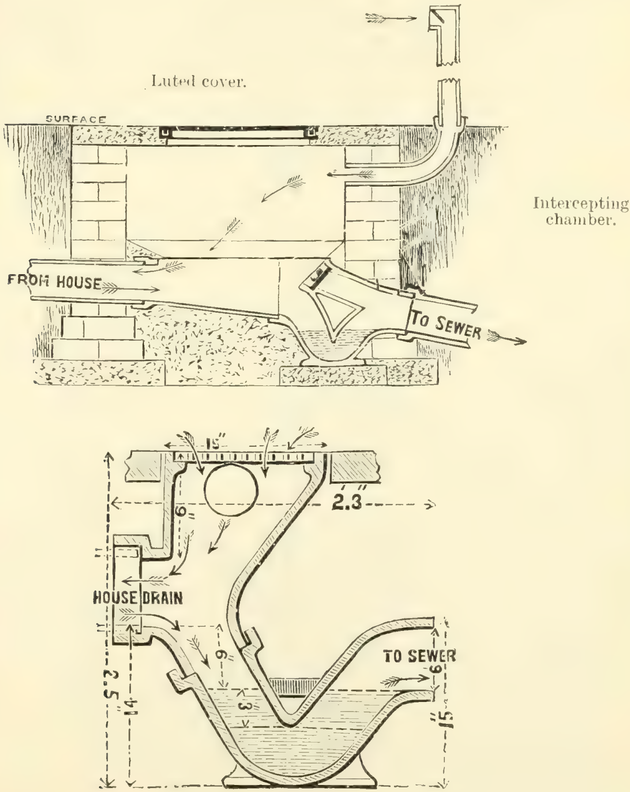
Provision should be made for flushing the house drain in addition to the incidental flushes given when the water-closets or lavatories are made use of.

DRAINS, LAVATORIES, WATER-CLOSETS.

The general aim in connection with the drainage of a building is to ensure a prompt and complete removal of all waste, deleterious matter, the retention of which may prove prejudicial to health.

This is effected by means of suitably arranged pipes or drains which shall convey the waste water from baths, lavatories, etc., but the removal of this and the construction of the pipes must be so arranged that, whilst they permit water to flow away into the sewers, they shall not permit the access back again of any gases, produced by decomposition, from the drains or sewers themselves into the building.

The object is attained by the use of simple ventilating traps, so placed as to afford no obstruction to the outflow of the liquid, whilst they effectually prevent the reflux of gases into



Section 6-in. interceptor.

FIG. 48.—Types of interceptors.

the building, the pressure in the sewers being relieved by appropriate ventilation into the open air. A trap is the name given to a bend placed upon the pipe in such a manner as to permit the flow of liquids but prevent the reflux of gases

(Figs. 48 and 49). The combined trap and fresh-air inlet is called an "interceptor."

The diagram (Fig. 50) indicates the principles to be aimed

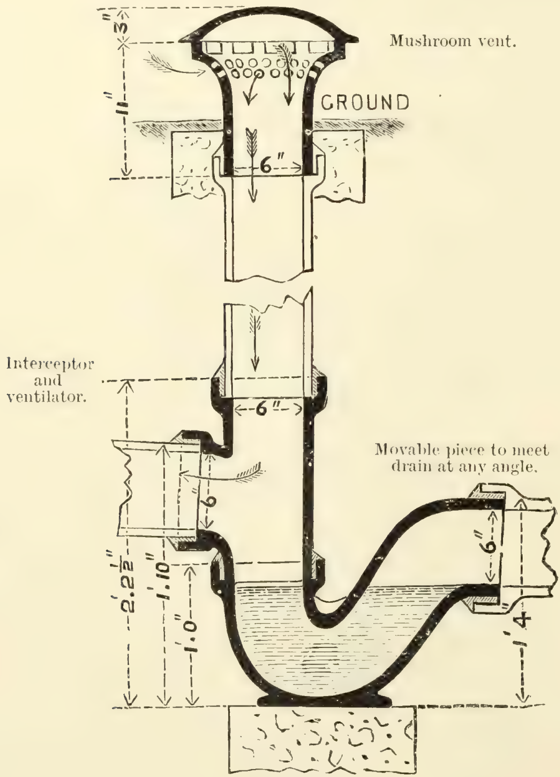


FIG. 49.—Type of interceptor.

at. The system coloured *red* indicates that section of the drainage system connected with the water-closet, and with the disposal of *foul water*. It will be seen that the outflows from the closets and the slops pass directly into the soil pipe, which, placed external to the building, is continued straight up

to the roof without bend or curve, and is open at the top full bore. Below, the soil pipe is directly continuous with the

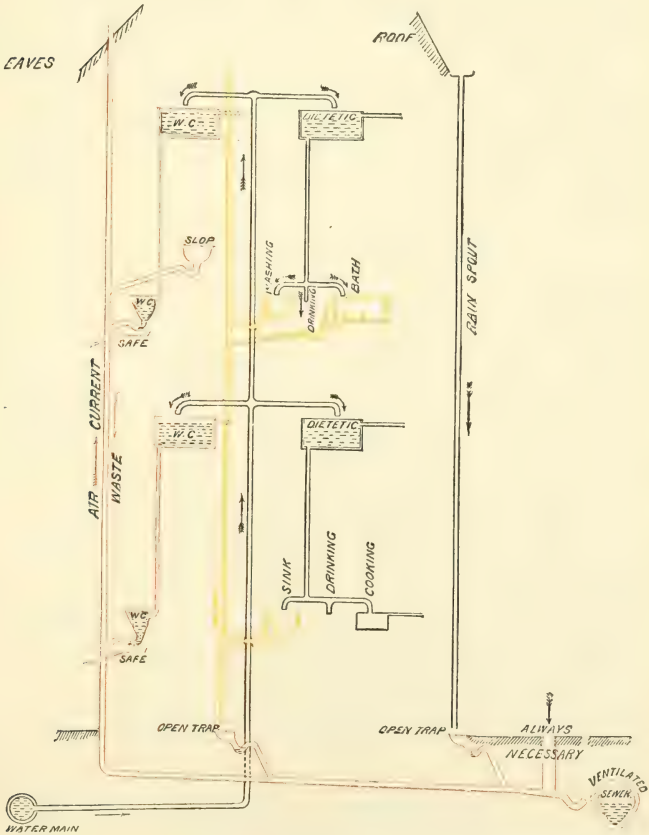


Fig. 50.

drain, which with an appropriate fall, to ensure sufficient velocity to its contents, passes first an open ventilator and immediately after that a trap, before terminating in the

ventilated sewer. Separate cisterns are provided for flushing the closets or lavatories. *Waste water* from baths and sinks is dealt with by the system coloured *yellow*, and it will be seen that the yellow pipes do not pass directly into the drain, but they terminate in the open air over a gully, which is itself trapped off from the drain. The *pure water* supply is indicated in *black*. Further, a long black line indicates the way in which the downspouts carrying off *rain water* are dealt with. These also terminate over trapped and ventilated gullies. They must not pass down into the drain direct, nor can they be made use of as ventilators for the drain, because in times of rainfall they are running full, and consequently cannot act as ventilators.

The Requirements of a Good House Drain.

1. A fall that will give a good velocity to the current. The velocity of the current should be about 3 feet per second, but to maintain this velocity it would require to run half full, so that a four-inch drain would require to be provided with water at the rate of 7·85 cubic feet per minute; a six-inch with 17·66 cubic feet per minute; and a nine-inch with 39·76 cubic feet per minute (Latham). The above is the theoretical requirement, but in practice a greater fall will be found necessary.

2. The most polished internal surface possible.

3. Good joints, allowing of no obstacle to the passing current, and preventing escape of sewage and gas.

4. A four-inch drain will be sufficient for most purposes. For large establishments, a six-inch is ample. Any increase in size above those mentioned is unnecessary, and increases the difficulty of cleansing by flushing.

5. Adequate means for flushing the drains periodically.

6. The connections or branches should never be at right angles. All T-joints *must* be prohibited, and Y-joints substituted.

7. *Good Traps.*—These need not be more than are absolutely necessary to prevent admission of sewer gases into the house, for "every trap in the line of a waste or soil pipe is necessarily a place for sewage to be arrested temporarily, and, if the use of the pipe be not very frequent, decomposition occurs, evolving gases."

8. A ventilating trap should be placed outside the house walls, on the main house drain, after it has collected all the branches which are tributary to it, and between this point and the sewer.

9. A good firm bed of concrete on which to lay the pipes, in order to prevent the settling and breaking of the pipes, or the pipes may be bedded in concrete.

10. Good ventilation is absolutely necessary. This may be effected by placing a ventilating trap, as just mentioned, and a ventilating pipe, starting from the highest point of the soil pipe, outside the closet trap; by this means sewer gas cannot collect in the soil pipe. The ventilating shaft should be of the same diameter as the soil pipe. The water conductor from the roof should never be used, for the compression of air in the sewer is most likely to occur during a heavy rain, when the pipes are otherwise engaged in carrying off the rain water.

11. *Traps.*—The best trap is the ordinary S bend or syphon trap. It may, however, become inoperative from the following causes:—

(*a*) The curve may not be deep enough to allow a certain depth of water to stand above the highest level of the water in the curve.

(*b*) The trap may be sucked dry if the pipe be small (2 and 4 inches) by the syphon action of the pipe beyond. This is most likely to occur if there be a sudden rush of water through the trap, and the pipes be running full. Also, if several syphons are used in the course of a drain, there may be one or all sucked dry by their united action; thus, *a b c* are three syphon traps placed in the line of a drain. If the drain, when running full, have the supply of water suddenly cut off, the result will be that a vacuum is created between *a b c; b* will therefore untrap *a*, and *c* untrap *b*, and *c* will itself be untrapped by the vacuum on the one side, and the force of the air on the other. To prevent this unsealing action, ventilators must be placed between the traps.

(*c*) In traps not used for some time the water may have partially evaporated, leaving the trap useless.

(*d*) If sufficient water be not used to thoroughly cleanse the trap, it may become clogged, and foul gases rise from it into the house.

(*e*) Pressure of air in sewer may force it; the water absorbing the sewer gas, and then giving it out on the opposite or house side.

(*f*) A piece of cloth or other material partly arrested in the trap may unseal it by capillary attraction.

The *Mid-Feather trap* is a syphon trap, with a projection from the inner surface of the shorter curve of the syphon

dipping into the water in the trap. This trap should be so made that access to it for occasional cleaning may be easy.

The *Flap-trap* is merely a hinged flap which allows the water to pass one way only. It closes by its own weight. It is used to close the mouth of drains, to prevent ingress of wind or water, and thus prevent regurgitation.

Bell-traps ought in all cases to be avoided. These were formerly in common use for sink traps, and as a rule the pipe was directly connected with the sewer.

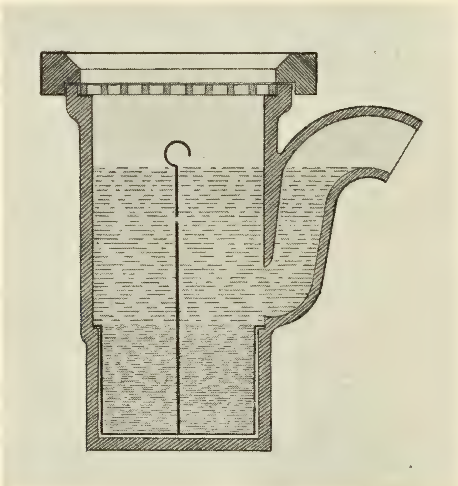


FIG. 51.—Dean's yard gully-trap. It contains an iron bucket to receive the detritus, which can be emptied periodically by taking out the bucket by means of the handle shown in the figure.

12. A means of access to the drain pipes should be provided for the purpose of cleansing periodically.

WATER-CLOSETS.

Water-closet basins should be so constructed that the trap is effectively flushed by the contents of the flushing cistern attached thereto. The simpler the design the better.

The types illustrated are :—

The valve.
The wash-down.
The syphonic.
The short hopper.
The "waste water" system.

The pan closet with D trap and container is a type of sanitary fittings now universally condemned.

Flushing cisterns should contain not less than three gallons, and may be of the

Single valve,
Compound,
or Syphonic type.

The automatic cistern is the fitting adopted to ensure systematic flushing in public urinals.

The best workmanship is needful to ensure satisfactory fixing of water-closet basins and the attendant fittings.

Lead safes should be fixed on all wood floors on which slop sinks or water-closet basins are to be fixed.

The walls and floors of rooms set apart for their accommodation should be of impervious material.

Much mischief is wrought by woodwork becoming saturated with liquid filth.

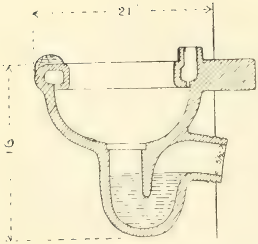
The Hopper Closet. — This consists of an earthenware funnel with a lead syphon trap, or better, with an earthenware trap in one piece, to which a ventilating pipe is attached. The advantages of this closet are : —

1. That the reservoir of foul air in the pan closet is dispensed with.
2. It can be easily cleaned.

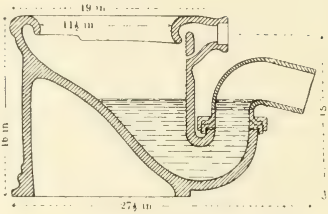
The disadvantages are :—

1. The contents of the trap are directly exposed; care is therefore required to flush it out immediately after it has been used.
2. Considerable waste of water may result from carelessness. This may be obviated by having a separate tank containing enough water for each flushing. On no account ought the supply of water for these closets to come direct from the mains.

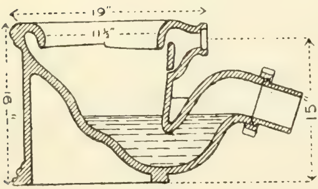
The Jennings Closet.—This has the advantages of the Hopper closet without its disadvantages. These are provided against by the use of a hollow plug, which, when lifted; allows all fæcal matter to be rapidly discharged, and, when down, retains a considerable quantity of water in the closet basin.



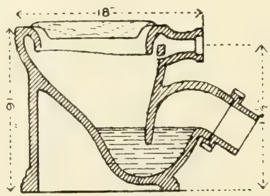
"Console" Hospital
Slop Hopper.



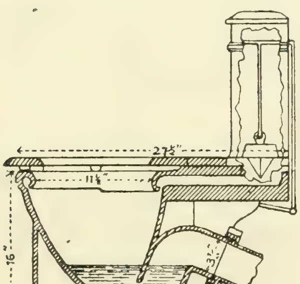
"Axis-Hospital,"
W.C. Basin.



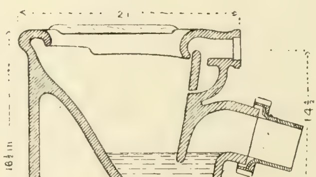
"Orion-Hospital,"
W.C. Basin



"Zone-Hospital."
W.C. Basin



"Ideal Convenient,"
with self-raising seat and
seat action fittings.



"Deluge-Adamant"
Hospital, W.C. Basin.

Fig. 52.

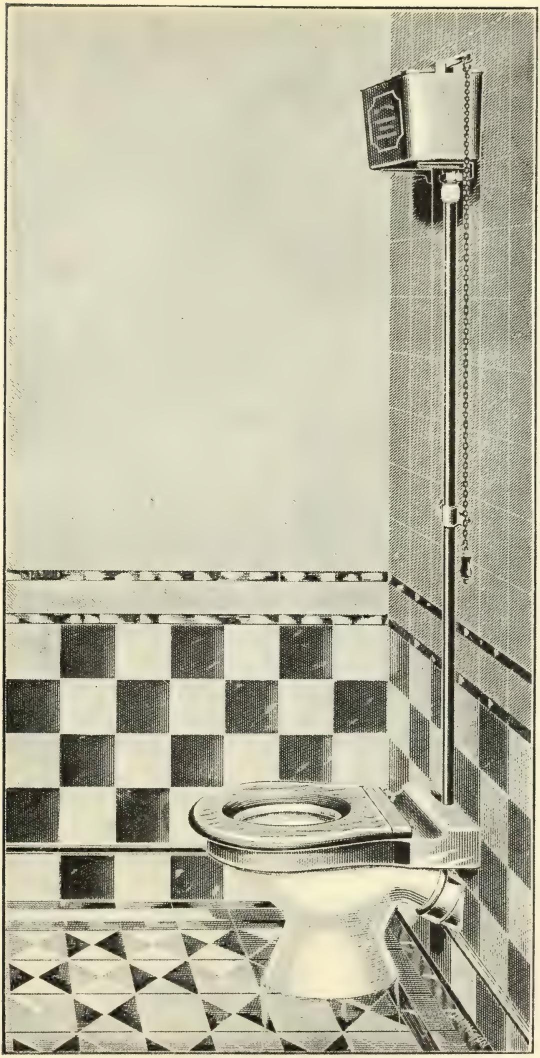


Fig. 53.—Hellyer's patent fire-clay "Neat" pedestal wash-down with extended top. Illustrating compact arrangement of W.C.

The foul reservoir of the pan closet is removed, and a larger water trap than the Hopper provided, with less waste.

The Bramah Closet.—This is a valve closet with a receiver, only large enough to allow of the full action of the valve. The receiver, although smaller than the ordinary pan closet, is open to the same objections. The trouble with these valve closets is that a piece of paper, etc., may unseal the valve by preventing it from fitting down in its seat.

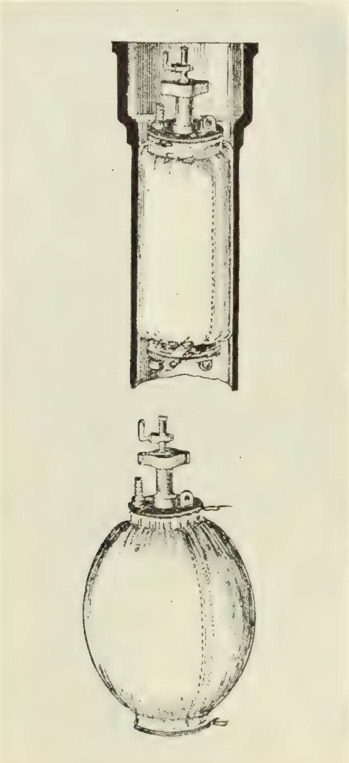


Fig. 54.—Bag drain or pipe stopper for testing drains or pipes by smoke, pneumatic, or hydrostatic test. (Burn Brothers' Patent.)

On the question of the ground air under and around houses, and the necessity for keeping it pure, Pettenkofer remarks: "They"—our neighbours—"can also poison the ground air for us; and I see more danger in this, as air is more universally present, and more movable than water."

The fewer waste pipes in the house the better, and under no circumstances should they be placed in bedrooms.

To test the Soundness of House Drains.

1. Draw up the closet handle, and notice if a flush of water passes the disconnecting trap outside the basement. If so, drain at least pervious.

2. Stop up trap, and fill pipe in the basement with water. If water remains at same level for some time, the pipe does not leak.

3. Fumes of paraffin or oil of peppermint should be passed in at the lowest part of the drain. After a time each room is

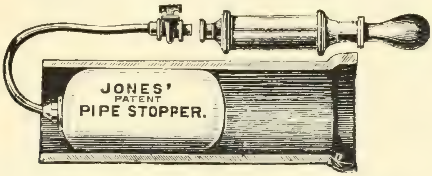


FIG. 55.—Pipe-stopper inflated by air-pump to close drain-pipe.

visited. If no odour of the substances used be detected, the joints and traps are perfect.

4. To test the ventilation of the pipes and traps, force into

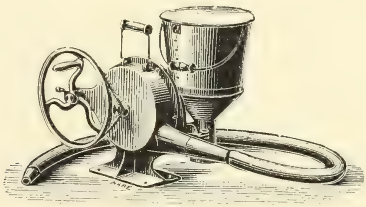


FIG. 56.—Smoke-testing machine.

the drain the fumes of paraffin, etc., under pressure, and then note if there be a smell in any room.

CHAPTER III.

SEWERAGE AND DISPOSAL OF SEWAGE.

In preparing a drainage scheme for a district, the following preliminary inquiries have to be made :—

1. The area of the district to be sewered.—This may be ascertained by a special survey, or from the Government ordnance maps.
2. The rainfall of the district, and the proportion it is intended to admit to the sewers.—The rainfall may be estimated by experiments, or by consulting Mr. Symond's Tables.
3. The geological character and physical outline of the district. —Obtained from local geologists or Government maps.
4. Present and prospective number of the inhabitants.—For this purpose the future population must be estimated by rules before given.
5. The water supply of the district.—This will to some extent regulate the supply of rain water to the sewers.
6. The sanitary appliances in use or to be adopted.
7. The nature of the outfall and the method of sewage disposal.
8. A good plan of the proposed sewerage scheme, to enable, in the case of stoppage, the easy finding of the sewers.

In constructing sewers the following points have to be considered :—(1) The best shape. (2) The external pressure to be borne by the sewer. (3) The minimum velocity required.

When the flow is constant and large, circular sewers are the best; but when the flow is intermittent, the oval should be adopted, so as to ensure the greatest velocity with the smallest volume of sewage. Circular sewers up to 18 inches in diameter are best made of earthenware or concrete, and no public sewer should be less than 9 inches in diameter.

Internal Dimensions of an Egg-shaped Sewer.

B = diameter of bottom of sewer.
C = diameter of top of sewer.

R = radius of sides of sewer.
D = depth of sewer.

$$B = \frac{D}{3}, \quad C = \frac{2D}{3}, \quad R = D. \qquad \text{(Molesworth.)}$$

Sewers built of brick should be well cemented, elliptical or egg-shaped, with the smaller end downwards, and with provision for subsoil drainage to prevent percolation of soil water into them. Sewers should, if possible, be laid in straight lines, and when curves are necessary, they should not be less than ten times the cross sectional diameter of the sewer. The junction of sewers by the interposition of man-holes should in all cases be adopted, but this arrangement is not applicable to back drainage, owing to the necessary interference with private property. All sewers should be laid sufficiently deep to enable cellars to be drained. The junctions from house drains should be made so that the discharge from them is in the direction of the established current. Junctions at right angles have a tendency to cause eddies by the inflowing sewage, and thus impede the main current. The more acute the angle of entrance the better. In the construction of sewers, allowance must be made for storm waters, and for this purpose intercepting sewers should be provided. These may be so constructed that they only come into use when the flow of fluid down the ordinary sewers is excessive. They are also very useful in sea-side towns, where, for some portion of the day, the main sewers are tide-locked. "In Paris the main sewers are made with paths on each side; just above the stream a tramway runs on one side, which carries a machine which can at once clear the bottom of the sewer; the entrance to each house drain is marked by a porcelain plate bearing a number; the owner of the house pays a small sum—three francs—annually to have his house drain kept clean."

Inclination and Velocity of the Current.—For a four-inch house drain, the inclination should at least be 1 in 92; for a six-inch, 1 in 137; for street sewers, 1 in from 50 to 300 feet, the fall depending somewhat on the size of the drain and the nature of the liquid and solid refuse it is intended to remove. Care should be taken that the fall is equable and not broken by varying gradients. The velocity for house drains should be about 180 feet per minute, and for street drains,

about 100 feet per minute. Sir Joseph Bazalgette recommends a velocity in large sewers of 176 feet per minute when running three-quarters full, 165 feet when running half full, and 146 feet when running one-third full. "The greatest discharge from a circular conduit is when it is not quite full —*i.e.* when rather better than fifteen-sixteenths full; and the greatest velocity occurs when it is thirteen-sixteenths full." The bottom velocity in a drain differs from the mean velocity in the ratio of from ·75 to ·85—say ·80 to 1—or four-fifths.

Man-holes and Lamp-holes.—These should be placed at convenient distances to allow easy access for examination and cleansing of sewer, and fitted with ventilating chambers filled with charcoal. Lamp-holes are small shafts, allowing of the suspension of a lamp, which may be seen from a man-hole along the sewer. Man-holes should be placed at every point of lateral deviation in a sewer, and man-holes or lamp-holes at every vertical point of deviation. Both man-holes and lamp-holes should act as ventilators.

Obstruction to Sewers.—This may be due to—

1. Improper levels used.
2. Too little fall.
3. Too sharp curves and bad connections.
4. Imperfection in the laying and making of the sewers, causing sinking of the floors.
5. Impediments at mouth of sewer from—
    - (*a*) Accumulation of mud, excreta, etc.
    - (*b*) Backward pressure of sewage, due to tides and wind.
    - (*c*) Want of proper supply of water to flush the sewers periodically.

The Cleansing of Sewers.—This should be frequently done, by flushing or otherwise, for a large amount of putrescent matter clings to the top and sides, due to the ever-varying level of the flow. The cleansing of sewers is now done by flushing. The rainfall must not be depended upon, for it is during the summer, when the rainfall is least, that the most injurious effects of an accumulation of filth are likely to result, increased also by the high temperature of that season. Artificial means are therefore required. In flushing sewers, commence at the lower parts of the district, and work gradually up to the higher parts.

The following Table is given by Denton :—

30	feet	per minute	will	disturb	clay with sand and stones.
40	,,	,,	will	move along	coarse sand.
60	,,	,,	,,	,,	fine gravel, size of peas.
120	,,	,,	,,	,,	rounded pebbles, 1 in. diameter.
180	,,	,,	,,	,,	angular stones, $1\frac{3}{4}$ in. diameter.

In some districts, where it is impossible to get proper gradients,

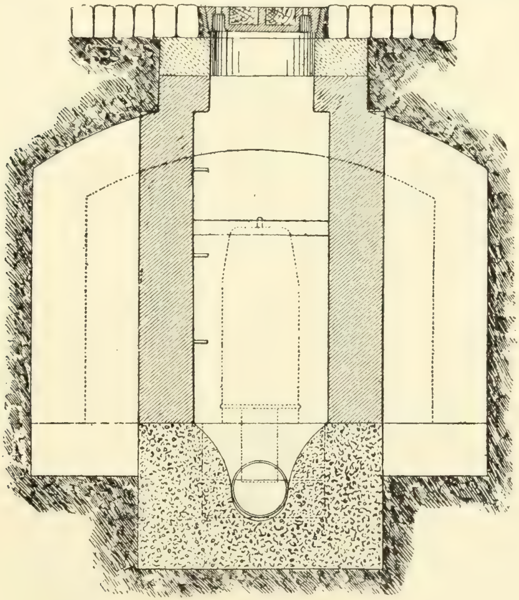


FIG. 57.—"Rogers Field" flushing syphon, in iron, for house use.

certain special appliances have to be adopted; thus Field's Automatic Flush Tank (Fig. 57) or Shone's Pneumatic Ejector may be used. The ejector is useful for discharging sewage into the sea or rivers against the rising tide. A sluice fixed in a sewer to regulate or control the current for flushing purposes is known as a *penstock*. It is necessary in tidal outfalls as an adjunct to tidal valves.

Ventilation of Sewers.—The difficulties in the sewerage of

a town are not ended when the sewers are completed, and the sewage turned into them. The sewers have to be ventilated. The generation and escape of sewer air is affected by—(1) Barometric pressure; (2) Temperature of liquids poured into sewers. In some towns ventilation has been attempted by open gratings in the street communicating with the sewers. Smell from the openings shows a need for flushing; if stopped up, the result may be that the sewer gas forces the traps and

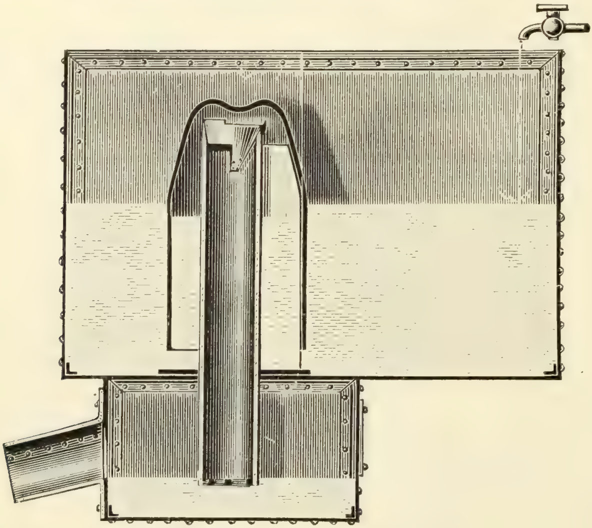


FIG. 58.—Transverse section "Rogers Field" syphon in carriage-way.

enters the houses. Ventilation is required even if the sewers have a good fall, or are flushed daily. Man-holes may be used if a tray containing charcoal be so placed as to intercept the gases as they rise. These charcoal ventilators are now, as a rule, condemned. An attempt was made in Southwark to ventilate the sewers by pipes connecting them with the furnaces of the soap works; the result was an explosion which blew "all the furnace down." But even where explosions do not occur, it is found that this method of ventilation is uncertain, and that the draught so created is so great as to open the house-

traps in the neighbourhood; "and when out of work, such inlets form outlets for the gases generated in the sewers, and therefore at such times disperse the sewer gases into the air of the streets and dwellings of the inhabitants of the district; or, in other words, such a system is violent, local, and intermittent in its application" (THORBURN). The best plan appears to be to connect the sewers with pipes carried above the tops of the houses, with an open top, or with Boyle's ventilator at their tops. The pipes should be of sufficient calibre to prevent the cold of winter condensing the sewer vapours on their sides, and thus blocking them. Care must be taken that the openings of the shafts are not near to windows.

Dry Methods of Disposal of Excreta.

In rural districts, and in some inland towns, the water-carriage system is inconvenient or inapplicable, and other methods are resorted to for dealing with excreta. It is well to remember that the daily amount of solid excreta per head averages $2\frac{1}{2}$ ozs., and of fluid 40 ozs. Thus, for a population of 1000 individuals, we will have daily 156 lbs. of fæces, and 250 gallons of urine, or with the same population a yearly amount of fæces 25 tons, urine 91,250 gallons.

The usual dry methods are—

A. Moule's Dry Earth Closet. *C.* The Goux System.
B. The Charcoal Closet. *D.* The Ash-pit.
E. The Pail System.

A. Moule's earth-closet labours under the following disadvantages:—

1. The trouble of providing a sufficient quantity of dry earth—at *least* one pound and a half for each dejection.
2. Difficulty of securing proper attention and removal of soil.
3. The trifling commercial value of product as manure.
4. The retention of excreta in the neighbourhood of houses.—This objection may be raised against all the dry methods.

The closets are fitted with pans containing dry earth, and may be used in sick-rooms, in the country, or for small communities, but their adoption will never be general. The best earths for use in these closets are—(1) rich garden surface mould, the best; (2) peaty soils; (3) black cotton soils;

(4) clays; (5) stiff clayey loams; (6) red ferruginous loams; (7) sandy loams; (8) sand and gravel, which are of no use.

The advantages of the dry-earth system are—

1. The earth-closet, intelligently managed, furnishes a means of disposing of excrements without nuisance, and apparently without detriment to health.

2. In communities, the earth-closet system requires to be managed by the authority of the place.

3. In the poorer classes of rural cottages, where supervision of any closet arrangements is indispensable, the adoption of the earth system offers advantages.

4. The earth system of excrement-removal does not supersede the necessity for an independent means of removing slops, rain-water, and soil water.

B. The Charcoal closet labours under the same disadvantages as Moule's closet.

C. The Goux system consists in collecting the excrement in tubs lined with dry absorbents. The tubs are about $16\frac{1}{2}$ inches high, and 20 inches wide at the top. Some dry absorbent, as sawdust with some disinfectant, is placed on the bottom, and on this is placed a solid plug about 4 inches in every direction smaller than the tub. The space between the plug and sides of the tub is now packed with more dry absorbent material, and the plug removed. The pails are distributed to the houses, and removed for emptying every two days, prepared pails being left in the place of those removed. The manure, as a rule, is almost valueless, and expense of removal great.

D. The Ash-closet has the same faults as the preceding. It was formerly in use in Salford and Manchester. The ashes from house fires are used.

E. The "Pail" System.—In this system the excreta are collected in pails containing some absorbent or deodorising material, and regularly removed by the sanitary authority. The pails, as a rule, contain crude aluminum chloride or cupric sulphate, and when full are emptied into a trench with fine ashes and about 30 lbs. of sulphuric acid to the ton. The contents of the trench are turned over till dry and then sold as manure. This plan is adopted in Rochdale.

The dry method is adopted to a great extent in India, where the proper fall for the sewers cannot be obtained, and in places where there is either an insufficiency of water or the

water for many months of the year is frozen. Where this system is adopted, the excreta are passed into proper receptacles, which in some cases allow of the fluid portions draining away; in others, the solid and fluid portions are collected and emptied daily on the land.

DISPOSAL OF SEWAGE.

Under all ordinary circumstances, the water-carriage system is the cheapest, cleanest, and most convenient, but it requires for its successful carrying out—

1. Good supply of water.
2. Good drains and sewers, with careful ventilation.
3. Sufficient fall to give the necessary velocity to the current.
4. Good subsoil drainage, apart from sewers.
5. A means of utilising the sewage.

The method may be divided under four heads—

1. The emptying of the sewage into a neighbouring estuary or into the sea.
2. The addition of disinfectants and other substances to precipitate the solid matter, and then allowing the liquid portion to pass into a river or the sea, as above.
3. The use of the sewage for the purpose of fertilisation by irrigation, and subsequent filtration through land before entering a river.
4. The application of biological processes, the aim being to promote and not to arrest decomposition. The incoming sewage is received into a closed tank, the effluent from the tank flowing slowly over coke-breese filters used alternately.

Of the disposal of sewage by the first plan, all that can be said against it is, that it is a great waste of valuable manure, and that by it we give to the sea what ought to be placed on the land. However, it is a significant fact that every community which can get rid of its sewage in this way, does so, and so avoids the greater trouble and greater expense of other methods.

With regard to the second and third methods, much discussion has arisen.

Against the second it is urged, that the solid part left after precipitation possesses little, if any, fertilising properties, and

that the various precipitating processes were found only to *clarify*, and not to *purify*, the sewage, the larger part—six-sevenths—of the matter, valuable as manure, going off in the effluent fluids. Besides the precipitate being almost useless, it is considerably in the way. The cost of material for precipitation is also considerable.

Many plans have been proposed for the defecation and purification of sewage, which, though successful in a sanitary point of view, have proved commercial failures, because the effluent from them all is essentially *sewage*.

The following are the four best known: (1) The Lime process. (2) The Phosphate of Alumina process of Messrs. Forbes and Price. (3) The Scott Sewage Company. (4) The A. B. C. process.

1. *The Lime Process.*—This process consists in the simple addition of a definite quantity of caustic lime, the amount added being in proportion to the strength of the sewage. This precipitates the whole of the suspended matter, with a certain amount of the dissolved constituents of the sewage. A fair degree of purification is thus obtained, and the effluent water is tolerably clear; but if allowed to stand for forty-eight hours, putrefaction takes place, which may, however, be delayed by the addition of chloride of lime. The precipitate possesses no fertilising properties, and is therefore of no value.

2. *The Phosphate of Alumina Process.*—This process of Messrs. Forbes and Price is a good one, but the materials used are too expensive to command success on a large scale. It consists in precipitating the sewage by the aid of the native phosphate of alumina dissolved in sulphuric acid, and then adding caustic lime. The process was carried on at Tottenham for some time; but, owing to the difficulty experienced in obtaining the native phosphate of alumina, the scheme has failed. The effluent water was not fit to run into rivers.

3. *The "Scott Sewage Company."*—This company proposes to make a sludge by adding slaked lime to the sewage, which causes a precipitate of the carbonates, phosphates, and silicates. Clay is then added to combine with the silica and the alumina, and the sludge thus formed, after being dried, is burnt into cement and lime. It takes one million gallons of sewage to produce two tons of Portland cement.

4. *The A. B. C. Process.*—The precipitating agent in this

scheme is a mixture of alum, blood, clay, and charcoal; hence the name. The sewage is mixed with a given quantity of the A. B. C. mixture and allowed to settle in precipitating tanks; the clear liquid is drawn off, and the sediment is dried and sold as manure, which is of little value. The Rivers' Pollution Commission makes the following remarks on this process:

(1) The process precipitates the greater part of the solid particles of the sewage, but in no case to such an extent as to allow the superincumbent waters to run into the river.

(2) The process produces no clearer water than what would have resulted if the sewage were allowed to settle by itself.

(3) The sewage is considerably reduced in value through it.

(4) Bad smells are always perceptible.

Composition of Sewage, from Sample obtained from the Southern Outfall, Crossness.

Total solid matter in solution	Mineral, 67·2; Organic, 13·3	=80·50
Total solid matter in suspension	Mineral, 8·8; Organic, 10·2	=19·00
Chlorine—chiefly as common salt		21·39
Nitrogen existing as ammonia		3·15
Organic nitrogen		0·70

(Greville.)

It has been proposed to treat sewage by passing an electric current through the sewage in a tank. Gases are formed which carry the solid matters to the top. The fluid is then agitated, the gases pass off, and the solid particles then settle to the bottom without any tendency to diffuse through the fluid again.

Filtration, Irrigation, Sewage Farms.—Both upward and downward filtration through sand, gravel, charcoal, sawdust, etc., have proved costly failures. A modified form of filtration is known as "Intermittent Downward Filtration," and appears successful. Several areas instead of one are in constant use, each capable of cleansing the whole sewage. Ridges and furrows divide the areas, and into the latter the sewage is run alternately, as the land is ready to receive it. Succulent vegetables are grown on the land in actual use. The sewage is only poured on the land during a portion of the day, so that there is a daily intermittency. The under drains are 6 feet below the surface.

The Rivers' Pollution Commission makes the following remarks on the method :—

Sewage traversing a porous and finely-divided soil undergoes a process to some extent analogous to that experienced by blood in passing through the lungs in the act of breathing. A field of porous soil, irrigated intermittently, virtually performs an act of respiration, copying on an enormous scale the lung action of a breathing animal ; for it is alternately receiving and expiring air, and thus dealing, as an oxidising agent, with the filthy fluid passing through it. The action of earth, as a means of filtration, must not be regarded as simply mechanical ; it is chemical, for the results of filtration, properly conducted, are the oxidation, and thereby the transformation, of the offensive organic substances, in solution in the sewage stream, into fertilising matter which remains in the soil, and into certain harmless inorganic salts which pass off in the effluent water.

Dr. Dyke mentions the following as requisites to the successful practice of this method :—

1. The soil of the land to be used must be porous.
2. A main effluent drain, which must not be less than 6 feet from the surface, must be provided.
3. The surface of the soil to be so inclined as to permit the sewage stream to flow on the whole land.
4. The filtering area should be divided into four equal parts, each part to be irrigated with the sewage for six hours, and then an interval of eighteen hours to elapse before a second irrigation takes place ; each of the four parts would thus be used six hours out of the twenty-four. An acre of the land so prepared would purify 100,000 gallons of sewage per day.

By allowing 15 gallons of sewage-polluted fluid per head per diem, the amount of land required for a given population can be calculated. Five acres well under-drained to a depth of 6 feet would be sufficient for a population of 10,000. One cubic yard will cleanse $4\frac{1}{2}$ to 10 gallons of sewage in twenty-four hours.

It has been suggested in regard to the use of sewage for the purpose of fertilisation by irrigation—

1. That the exhalations from sewage farms may become a source of disease—enteric fevers, etc. This has not been verified by experience where proper precautions as to subsoil drainage, etc., have been taken.
2. That the vegetable growth of such farms, even when the process of irrigation is carefully conducted, is exceedingly rank, and may give rise to disease in man and animals. Dr. Spencer Cobbold's theory is that the sewage brings down the eggs of the tapeworm and disease germs, and that, during the course of the sewage over the land, some of the germs adhere to the growing plants. That when an animal eats such sewage produce, the ova of the tapeworm are developed, and cysts

are formed in the flesh of the animals. His theory has, however, not been corroborated. If the sewage be allowed to become stagnant on the grass, bad results *may* follow, but not when proper care is taken.

3. That there is frequently a difficulty in obtaining sufficient land for the complete and effectual disposal of the sewage of large towns. The difficulty is increased in proportion to the size of the town, for the required land may be large, and the price considerable—one acre for every hundred and fifty persons. It must also be remembered, when irrigation is relied upon as a means of disposing of large volumes of sewage, *that the supply is continuous*, while the land is always in varying states to receive it, being in wet weather already saturated with water. This cannot occur if proper methods of drainage are adopted, and due care taken to divert storm-water and prevent it reaching the sewage farm. In England, irrigation may proceed all the year round. An objection to sewage irrigation, which must not be overlooked, is the possible contamination of the neighbouring water supply by filtration of the sewage through the earth.

The best site for a sewage farm is a gentle slope: the land must, however, not be too retentive or too porous. An acre must be allowed for every 100 of the probable population. At Berlin, one acre for about 150 persons is allowed. Italian rye grass, cabbages, swedes, etc., appear to be the best crops.

The Bacterial Purification of Sewage.

The aim in these processes is not to arrest, but to favour decomposition, attempts being made to effect liquefaction of the solid matters in sewage in the same manner that it is known to have taken place in the old underground cesspools, in which, as is well known, the amount of solid deposit accumulating after prolonged periods was very small. The liquefaction and disappearance of the solid constituents of the sewage are due to bacterial action. The subject was experimentally investigated by the State Board of Health in 1888 and subsequent years, and since that date much attention has been paid to it. The "septic tank" system was introduced by Mr. Cameron of Exeter in 1895, the principle being to subject the sewage to preliminary treatment in tanks from which light and air as far as possible were excluded; the deposit, owing presumably to the action of anaerobic organisms, was small, whilst the scum collecting on the surface was subject to the action of aerobic organisms. The liquid sewage flowed subsequently over coke-breese filters. The experiments carried out during 1902 by Dr. Clowes, under the instructions

of the London County Council, are very satisfactory. They and their results may be summarised as follows :—

The raw sewage, which has been screened from its coarser matters only, is pumped into a settling tank, the rate of supply being so adjusted that the sewage remains about six hours in the tank before it flows away through an elbow-pipe from beneath the surface of the liquid.

In this tank practically the whole of the suspended or floated particles of the sewage settle as sludge, and are allowed to remain undisturbed. About 50 per cent of the sludge disappeared by bacterial action, and the part which disappeared was the most putrescible portion.

The sewage in the tank, after settling, flows into a coke-bed, which is a tank filled with suitable coke fragments to the depth of 6 feet. As soon as the bed is filled to the surface of the coke the supply is stopped, and the sewage liquid allowed to remain in contact with the coke for two hours. It is then drained off from the bottom of the bed, and constitutes "bacterial effluent." The coke-bed then remains empty for two hours prior to being refilled with fresh supply of sewage.

By this treatment the sewage is rendered sufficiently pure to support the life of fish, and to ensure it against undergoing any offensive change, even in summer time.

Dr. Clowes summarises his experiments as follows :—

1. That by suitable continuous undisturbed sedimentation the raw sewage is deprived of matter which would choke the coke-beds, and the sludge which settles out is reduced in amount by bacterial action to a very considerable extent. This reduction might undoubtedly be increased by the preliminary removal of road detritus.

2. That the coke-beds, after they have developed their full purifying power by use, have an average sewage capacity of about 30 per cent of the whole space which has been filled with coke.

3. That the sewage capacity of the coke-bed, when the bed is fed with settled sewage, fluctuates slightly, but undergoes no permanent reduction. The bed does not choke, and its purifying power undergoes steady improvement for some time.

4. That coke of suitable quality does not disintegrate during use.

5. That the "bacterial effluent" of settled sewage from the

coke-beds does not undergo offensive putrefaction at all, even in summer heat, and can never become offensive. That this effluent satisfactorily supports the respiration of fish.

6. That the use of chemicals is quite unnecessary under any circumstances when the above method of treatment is adopted.

There can be no doubt that the pouring of the sewage of a town into a neighbouring stream is an unmitigated evil. Some authorities have maintained that running streams have a self-purifying power, and that organic matter is almost completely oxidised by the oxygen of the air, and by that contained in the water.

The Rivers' Pollution Commission state, on the experiments made by them with a view to the solution of this question, that "it will be safe to infer, however, from the above results that there is no river in the United Kingdom long enough to effect the destruction of sewage by oxidation."

Two modifications of the water-carriage system of removal of sewage call for mention, viz. Liernur's method and Shone's method.

Liernur's Method.—This plan consists in drawing the excreta from the closets of a town by creating a vacuum, by means of an air-pump worked in some central station in the town. From this central station pipes radiate in all directions through the town, following the principal streets. At varying distances along these pipes, reservoirs are sunk below the pavement, which are filled directly from the house closets, and are then emptied by the continued action of the air-pump. By a system of stop-cocks, which can be turned on and off, any district may be cleared at pleasure. On reaching the central station the excreta are decanted in a fluid form in barrels, for immediate transport to the country, by means of hermetically closed apparatus. The closets are very simple, consisting of a double funnel, the space between the two communicating by a pipe with the external air. No water is required. The excrement falls into a sort of hydraulic trap, capable of holding the fæcal products of but one person, and compelling what is held before to fall into a larger trap of four times greater capacity. This latter discharges in the branch tube, which is connected with the main tube, and empties into the street reservoir. By a succession of short bends, repeated at regular

intervals, all metal valves which are likely to get out of order are avoided, the fæcal mass practically forming the required temporary closure from the main pipe. A separate system of sewers for rain water, street drainage, slops, and for the drainage of the soil is necessary. This method has been adopted in some of the towns of Holland, at St. Petersburg, at Prague, etc.

The advantages claimed for this method are that the pipes, which are emptied daily, are of iron, with well-made joints, and that if a hole exists in the pipe the pressure is inward and matters are "sucked in," thus closing it up. There are no valves, only cocks which are easily attended to, and the closets are without water, and ventilated from the funnel-shaped closet and also from the soil-pipe. Pipes are not liable to be stopped by improper substances thrown into them.

The following are the objections against the adoption of this method :—

1. The primary cost is great, especially as it provides for the removal of excrement alone.
2. The escape of sewer gas from the sewers, and from the plug or trap of excrement.
3. The not unfrequent overflowing of the closets, by becoming clogged with coffee-grounds, ashes, rags, etc.
4. The necessity of frequently flushing the closets, thus diluting the sewage.
5. The sewage may become frozen in winter, and therefore useless.
6. The difficulty of disposing of the sewage during winter and summer at a remunerative price.

Shone's Method.—This system of sewerage is claimed to be applicable wherever the sewage of a town or district requires to be lifted, and may be briefly described as a system of distributed stations for the lifting of sewage, worked from one central station by means of compressed air, whereby the whole drainage area is divided into a number of compact districts, each with its separate outfall and discharging station, the discharge from all the stations converging into one common main leading to the ultimate common outfall.

Fig. 59 gives a sectional view of a Shone pneumatic ejector of ordinary construction, suitable for raising water, sewage, sludge, etc. Ejectors are made of any size or shape convenient for the special circumstances for which they are required. For sewage, sludge, and pail contents, prefer-

ence is given to those having the lower portion of hemispherical shape.

The motive power employed is compressed air, and the action of the apparatus is as follows :—

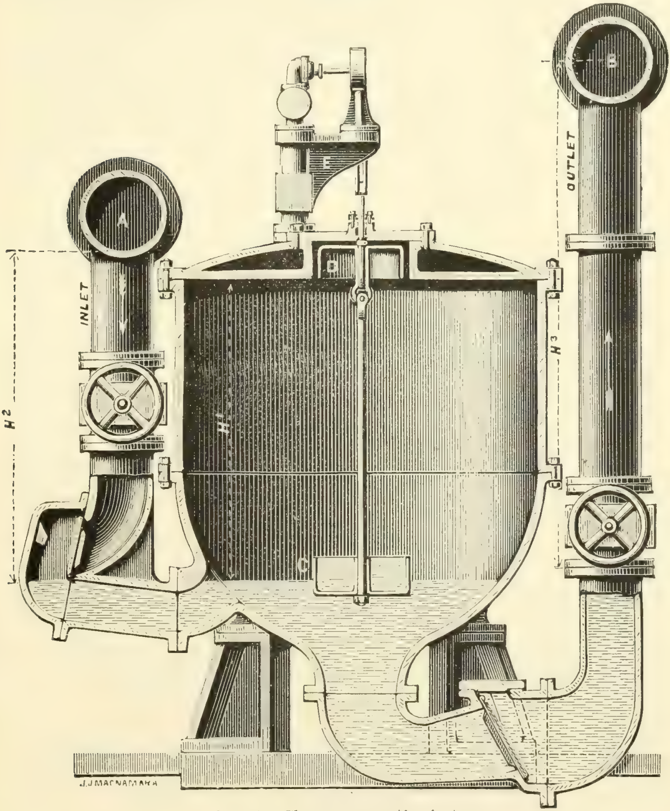


FIG. 59.—Shone pneumatic ejector.

The sewage gravitates from the sewers through the inlet pipe A into the ejector, and gradually rises therein until it reaches the under side of the bell D. The air at atmospheric pressure inside this bell is then enclosed, and the sewage,

continuing to rise outside and above the rim of the bell, compresses the enclosed air sufficiently to lift the bell, spindle, etc., which opens the compressed air admission valve E. The compressed air thus automatically admitted into the ejector presses on the surface of the sewage, driving the whole of the contents before it through the bell-mouthed opening at the bottom, and through the outlet pipe B into the iron sewage rising main or high-level gravitating sewer, as the case may be. The sewage can only escape from the ejector by the outlet pipe, as the instant the air pressure is admitted on to the surface of the fluid the valve on the inlet pipe A falls on its seat and prevents the fluid escaping in that direction. The fluid passes out of the ejector until its level therein reaches the cup C, and, still continuing to lower, leaves the cup full until the weight of the liquid in the portion of cup thus exposed and unsupported by the surrounding water is sufficient to pull down the bell and spindle, thereby reversing the compressed air admission valve, which first cuts off the supply of compressed air to the ejector and then allows the air within the ejector to exhaust down to atmospheric pressure. The outlet valve then falls on its seat, retaining the liquid in the sewage rising main, and the sewage flows into the ejector through the inlet once more, driving the free air before it, through the air valve, as the sewage rises; and so the action goes on as long as there is sewage to flow.

The positions of the cup-and-bell floats are so adjusted that the compressed air is not admitted to the ejector until it is full of sewage, and the air is not allowed to exhaust until the ejector is emptied down to the discharge level.

The compressed air for actuating the ejector is produced at some central station, and conveyed in iron pipes laid under the streets to the several ejector stations.

Several Useful Formulæ.

CALCULATION OF DISCHARGE FROM SEWER.

$$V = 55 \times (\sqrt{D} \times 2F) \times A.$$

V = velocity in cubic feet per minute. D = hydraulic mean depth.
F = fall in feet per mile. A = section area.

First ascertain the hydraulic mean depth where the sewage is flowing, and the amount of fall in feet per mile.

The hydraulic mean depth is one-fourth the diameter if the pipe be running full; if the pipe be not full, it is the section area divided by the wetted perimeter.

The wetted perimeter is that part of the circle of the pipe wetted by the fluid.

To find the fall in feet per mile, measure a distance of 50 or 200 feet, and calculate fall 5280 feet = 1 mile.

Multiply the hydraulic mean depth by twice the fall in feet per mile, and take the square root. Multiply the square root by 55, and result by the section area; this will give the amount in cubic feet per minute (PARKES).

To find the velocity of any given head, take the square root of twice the gravity and multiply it by the square root of the given head.

P = pressure in pounds per square inch.
H = head of water in feet.
V = velocity (theoretical) in feet per second.
g = force of gravity.
$P = H \times \cdot 4335. \quad H = P \times 2 \cdot 307.$

Pressure per square foot = H 62·4.

$$g = 32 \cdot 2. \quad 2g = 64 \cdot 4. \quad \sqrt{2g} = 8 \cdot 025.$$

$$V = \sqrt{2gH} = 8 \cdot 925 \sqrt{H}.$$

$$H = \frac{V^2}{2g} = \cdot 0155\, V^2. \quad \frac{1}{2g} = \cdot 0155.$$

VELOCITY IN STRAIGHT PIPES.

$$V - 26 \cdot 76 \sqrt{\frac{Dz}{L}}.$$

D = diameter of pipe. z = altitude of the head of water.
L = length of pipe in feet.

FLOW IN SEWERS.

X = area of sewer ÷ the wetted perimeter in feet.
f = fall in feet per mile.
V = velocity in feet per minute.
A = area in square feet.
C = cubic feet of water delivered per minute.

$$V = 55 \sqrt{X \times 2f}. \quad C = V \times A.$$

USEFUL DATA.

1 cubic foot of water		= 62·425 lbs. = ·557 cwt.
1 cubic inch	,,	= ·03612 lb.
1 gallon	,,	= 10 lbs. = ·16 cubic foot.
1 cubic foot	,,	= 6·24 gallons, say 6¼.
1 cwt.	,,	= 1·8 cubic feet = 11·2 gallons.

To calculate the volume of water discharged from a pipe :—

$$39{\cdot}27\sqrt{\frac{hd^5}{1}} = \text{V in cubic feet per second.}$$

Ex.—The diameter of a pipe is 1 foot, the head of the flow 9, and the length of the pipe 9000 feet ; what is the volume of discharge ?

$$39{\cdot}27 \times \sqrt{\frac{9 \times 1}{9000}} = 39{\cdot}27 \times \sqrt{{\cdot}001} = 1{\cdot}242 \text{ cubic feet.}$$

Discharge of Water in Pipes or Sewers for any Length and Head, and for Diameters from 1 to 12 Inches, in Cubic Feet per Minute.

Diameter.	Tabular No.	Diameter.	Tabular No.
1	4·71	4½	194·84
1¼	8·48	5	263·87
1½	13·02	6	416·54
1¾	19·15	7	612·32
2	26·69	8	854·99
2½	46·67	9	1147·6
3	73·5	10	1493·5
3½	108·14	11	1894·9
4	151·02	12	2356·0

The formula to construct this Table is as follows :—

$$\frac{2356\sqrt{d^5}}{\sqrt{\frac{1}{h}}} = \text{V}.$$

d = diameter ; h = height of fall of water in feet.

(See Haswell's *Mechanic's Pocket-Book.*)

CHAPTER IV.

WATER.

WATER is a fundamental sanitary necessity; the supply should be liberal. A scanty and insufficient water supply, or the scanty use of available water, means every form of sickness associated with filth, whilst an impure supply will result in a variety of forms of disease.

The uses to which water is put suggest the nature of the evil which results from restricted supply: for drinking and cooking, for public and private baths, washing of clothing, utensils, and house, water-closets, etc., for cleansing streets, washing drains, and flushing sewers water must be freely available; other important uses, more especially in towns, are for the cleansing of animals and their surroundings, for trade purposes, for extinguishing fires, and for ornamental purposes.

A very important as well as pleasant means of promoting the health of towns is by open spaces, parks, and gardens. Well-understood benefits result from vegetation, grass, shrubs, and trees, maintained in a healthy and vigorous condition. Rainfall must, to a great extent, be depended upon for this, but if it is possible to supplement rainfall by watering, much mischief will be averted. The vegetation of many city gardens and squares, and the sites of disused burial-grounds, might be kept in a healthier condition if a more liberal supply of water were given.

Quantity of Water required.—The amount of water consumed in towns is estimated in gallons per head per day; the quantity varies in different places, frequently in accordance with the facility in obtaining it.

It is of interest to note what some of these quantities are:—

Glasgow	receives	50 gallons per head per day, of which 32 are estimated to be for domestic purposes.		
Edinburgh	,,	35 gallons per head per day.		
Aberdeen	,,	48	,,	,,
Leeds	,,	33	,,	,,
Dublin	,,	32·6	,,	,,
London	,,	35	,,	,,
Liverpool	,,	30	,,	,,

Manchester, and some other inland towns, have a less supply, in consequence of the dry-closet systems adopted. Abroad, and in America, the supply is very much more liberal. In Paris, where, as is well known, a liberal use is made of water, 47 gallons per head per day are allowed. In New York and other prominent American and Canadian cities the supply is very much more liberal even than that. It may perhaps be true that in American cities which have a supply of over 100 gallons per head per day, a considerable amount is wasted. Waste of any kind is to be deplored, but no question of waste arises so long as it can be proved that the increased use results in preserving health and removing dirt and discomfort.

Water, as a sanitary necessity, ranks almost with sunlight and fresh air, and if the construction of some parts of great towns prevents the access of these, there is greater need that there should be unrestricted use of water.

With regard to the manner in which the daily supply is disposed of, it may be reckoned that of an average daily supply of 35 gallons per head, 12 gallons go for ordinary domestic purposes, including 1 gallon for food and cooking, 6 gallons for additional baths, 4 for water-closets, 3 for unavoidable waste, 10 for municipal and trade purposes; this latter is perhaps a low estimate. Professor Rankine's estimate is as follows:—

	Gallons per Day per Head.
Used for domestic purposes	15
Washing streets, extinguishing fires, supplying fountains	3
Allowance for trade and waste	7
Additional demand in manufacturing towns . . .	10
Total in manufacturing towns	35

Parkes maintained that for personal and domestic use, without baths, 12 gallons should be the minimum daily supply; with baths, 16 gallons; this did not include water-closets, which

require 4 to 6 gallons per head. Taken altogether, provision should always be made for a daily minimum supply of 35 gallons per head, with an additional allowance of 3 gallons for unavoidable waste. For hospitals, from 50 to 100 gallons should be allowed.

The amount of water required for the use of animals may be estimated at 11 to 16 gallons per day for a horse, 8 to 10 for a cow, and so on for other animals.

Public baths should be erected and freely supplied with water, which should, if possible, be kept constantly flowing in and out.

After frost there is usually great waste, owing to bursts in pipes.

The following important questions connected with a water supply require consideration :—

1. Selection of purest available source.
2. Filtration, if necessary.
3. Storage in covered tanks for distribution by gravitation.
4. Method of collection—
   - (*a*) Mountain ranges.
   - (*b*) Rivers and streams.
   - (*c*) Natural springs.
   - (*d*) Wells.
   - (*e*) Impounding reservoirs.
   - (*f*) Subsoil drainage (DENTON).
   - (*g*) Combination of any of the above.
5. How stored—
   - (*a*) General. Covered reservoirs.
   - (*b*) Private. Cisterns.
6. Method of distribution—
   - (*a*) Open conduits before filtration.
   - (*b*) Covered conduits *after* filtration.
   - (*c*) Cast-iron pipes under pressure.
7. Composition and characters.
8. Dangers of pollution—
   - (*a*) At source.
   - (*b*) At any point during distribution.
   - (*c*) Private storage.
9. Quantity per head.
10. Effects of water on animal economy—
    - (*a*) Healthy.
    - (*b*) Producing disease.

Sources of Water Supply.

Rain is the ultimate source of all water supply, whilst rain in turn is due to the great purifying process of distillation by the sun's rays from all moist surfaces of the globe. Rainfall is, in part, at once evaporated, but that which flows over the surface constitutes streams, rivers, and lakes; that which sinks into the porous formations upon which it falls is checked by the impervious strata ultimately reached, and it then accumulates in the porous strata, or finds its way to the surface in the form of springs. Upon sand or gravel 90 per cent of rainfall passes into the ground, upon chalk 40 per cent, limestone 20 per cent, clay scarcely any.

1. *Rain Water* ranks next in purity to distilled water, but may become contaminated by passage through the air. As a supply to large towns, it must not be trusted, unless adequate means are employed to impound it in lakes, for the following reasons:—

(1) Uncertainty of supply. To estimate the rainfall as a source of supply, take the rainfall of the three consecutive driest years.

(2) The quantity falling in an inhabited country is small in proportion to the number of the inhabitants.

(3) Not very palatable to the taste.

(4) Expense in collecting, and liable to become contaminated by storage.

(5) In manufacturing towns, rain water may contain sulphuric acid, and also be more or less impregnated with soot.

If used by small communities, rain water should not be allowed to remain in lead, but in slate cisterns of small size, or in tanks sunk deep in the ground to prevent evaporation, and it should be collected as pure as possible. Gibraltar, Venice, and Constantinople are so supplied.

To find the amount of rain water that can be collected from any roof, reduce the area to square inches, multiply by the rainfall, and the result by ·003607 to find the number of gallons supplied, or by ·00058 for cubic feet. One inch of rain gives 4·673 gallons for every square yard, or 22,617 for each square acre, or 4840 square yards; hence, given rainfall in inches and number of inhabitants, calculate extent of "catch" ground required to supply 50 gallons daily per individual. (See "Useful Formulæ," pp. 492 *et seq.*)

2. *Snow Water.*—Not pleasant to the taste, and is said to cause gastric derangement.

In Moscow, cholera has occurred in the winter owing to the inhabitants throwing the choleraic dejections on the snow round their houses, and then melting it for domestic purposes. Water from melted snow is largely used by the farmers of Manitoba.

3. *Spring and Well Water.*—Water from these sources varies greatly in composition.

(1) Always much harder than lake or river water.

(2) Superficial wells apt to contain organic matter from churchyards, cesspools, etc., and also salts, sulphates, and carbonates of lime the latter kept in solution by excess of carbonic acid. By an improved system of subsoil drainage,

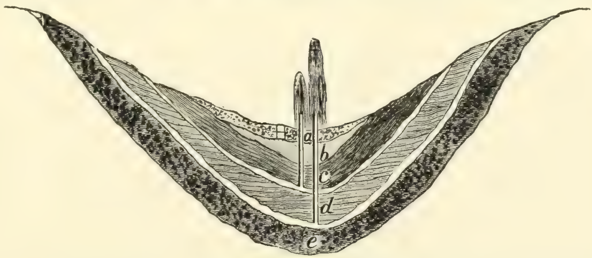


FIG. 60.—Figure represents a vertical section of geological strata of a water-bearing basin. *a*, layer of loose sand and gravel; *b*, bed of clay; *c*, stratum of slate; *d*, limestone stratum; *e*, a stratum of granite. The upright shafts are spouting bore-tubes or artesian wells.

the waters from these wells may be rendered pure and wholesome.

(3) Deep wells contain much lime, sometimes as much as $1\frac{1}{4}$ tons of chalk per 1,000,000. Deep wells, however, from an engineer's point of view, are perhaps the best source of drinking water, but they are open to several objections:—(*a*) Cost of sinking. (*b*) Drying up other wells in their vicinity. (*c*) Insufficiency of the supply. (*d*) Expense of raising water from great depths. (*e*) After great expense in sinking, no water may be obtained, or if found, it may be salt or brackish.

(4) Artesian wells may contain large quantities of the alkaline carbonates and sulphate of lime.

AN ARTESIAN WELL—from Artois in France—is a deep well

bored through impervious strata to a water-bearing stratum in which the water is under such a pressure as to cause it to rise to the surface. The Artesian well at Grenelle drains a district above 100 miles distant from Paris. These wells have been used in China from remote antiquity.

Sometimes a spring may appear on the side of a hill, owing to a "fault" in the water-bearing strata. The "American," "Abyssinian," or "tube wells" are made by driving a cast-iron tube about two inches in diameter into the ground. The tubes are in short lengths, screw into each other, and are then driven down till water is found. These wells are useful in supplying water to an army. They, however, failed in the Ashantee War, from their becoming clogged with sand.

4. *River Water* may contain organic matter from sewage, and also impurities from the soil, etc. As a rule, river water is very pure.

5. *Lake Water* is also a pure water. Glasgow is supplied from Loch Katrine, which is one of the purest known natural waters, containing only about $2\frac{1}{2}$ grains of solid matter per gallon.

6. *Marsh Water* is most impure.

7. *Peaty Water* is not injurious, though unpleasant to the taste.

Impounding Reservoirs are formed by throwing a dam across a valley through which a stream flows, and thus forming an artificial lake. Edinburgh is largely supplied by water from an impounding reservoir in the Moorfoot Hills, from which the water is brought by gravitation to the town.

The dam across the valley of the Vyrnwy in Wales was constructed to impound the waters of the great watershed of the locality, with the object of forming a lake sufficiently large to supply Liverpool and its vicinity. Lake Vyrnwy is nearly five miles in length, and half a mile in width. The water is of great purity; the large area of the collecting ground is owned by the Corporation of Liverpool, and kept scrupulously clean and practically free from habitations.

Storage of Water—Filtration.

Although in the majority of towns the supply of water is maintained at a pressure which enables it to be drawn off in

houses at all times, yet it is customary to store some in cisterns, to feed boilers, or for other emergencies. In some places, however, water is only supplied at stated intervals, and hence the storage becomes a necessity. The two systems are known as the *constant* and *intermittent* respectively.

The advantages of the constant service are obvious; except for closet cisterns, or for everyday purposes, storage is not necessary. When the constant system is adopted, only "screw-down taps" of the best description should be allowed; a small cistern must be connected with each closet, containing three gallons—enough water for one "flush." It has also been suggested to put the service pipes in the poorer neighbourhood of a town in such a position on the landings that neglect shall cause such inconvenience as to enforce care.

The provision to be made for storage for public use will depend upon the consumption, calculated at so much per day for each individual of the estimated population of the district. In London, for instance, the water supplied by the New River Company is taken from the New River and the Lea, and a few ponds. The water is first collected in a large reservoir, and then passed into the filters, which are brick tanks open to the air, the bottoms of which are covered with 4 or 5 feet of sand and coarse gravel in the following order, beginning from the bottom:—A layer of bricks, 6 inches deep, then 6 inches of gravel; and, lastly, a layer of sand, 2 feet 6 inches deep—on the surface of the sand, the water is 5 feet deep. This arrangement allows of a filtration of 4·5 cubic feet per hour. It has been found that the active portion of the filter is about half an inch in depth of the upper layer of sand, and this has to be removed, in some cases, every two months, washed with water, then relaid, and again used. Through this bed of sand and gravel the water has to percolate before it reaches the filtered water reservoir, whence it is pumped to the reservoirs of the Company, placed on the highest parts of the neighbourhoods supplied by the New River system. After filtration, the water should be kept in covered reservoirs to protect it from the sun and from contamination. The rate of filtration should not exceed 700 gallons per square yard of filter-bed in twenty-four hours. For the domestic purification of waters small filters are used. These act in two ways, mechanically and chemically. Thus *mechanical* action consists

in removing all suspended impurities, the *chemical* in oxidising deleterious organic products. The best materials for this purpose are animal charcoal and magnetic carbide of iron, prepared by roasting a mixture of hematite with sawdust. The Pasteur-Chamberland filter consists of a cylinder of porous unglazed porcelain, through which the water passes. The Berkefeld filter is made of infusorial earth. Many other materials have been proposed, "spongy iron," *carferal*, a mixture of charcoal, iron, and clay; but Professor Frankland is so strongly in favour of animal charcoal that, in spite of its great cost, he would employ it on a large scale for the purification of town supplies. The worst possible material for filters is sponge.

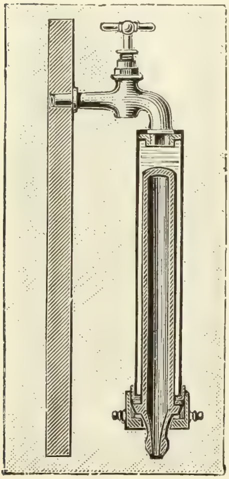


Fig. 61.—Pasteur-Chamberland filter.

The points in a good filter are—(1) Easy access to the filtering material. (2) Perfect cleanliness. (3) Frequent changing or purification of the filter.

Charcoal filters may be purified by frequently brushing their surface, boiling in hydrochloric acid, and then passing through them a solution of permanganate of potash.

Private Storage.—For the private storage of the inhabitants slate, lead, iron, galvanised iron, and zinc cisterns are used. The first are the best, but cisterns of zinc are most used, on account of the cheapness of the material. Lead is open to the objection of the poisonous nature of the soluble compounds sometimes formed by the action of the water on the metal. Slate cisterns are difficult to keep watertight; and if iron ones are used, they should be coated with the patent material used for water-mains. All cisterns should be kept covered to prevent contamination, but free ventilation should be provided. They should also be placed so as not to damage the house or render it damp in case of leakage, and also be easy of access for inspection, cleaning, etc. Care must be taken that the waste does not communicate with the drains or closet-tap, but

that it opens into the open air. A common practice in London is to carry the waste pipe into the closet-trap. All cisterns should be inspected and cleaned periodically.

In their report on the storage of water in houses, the Rivers' Pollution Commissioners remark :—"All storage of drinking water in houses is attended with the risk of pollution. Good water is spoiled, and bad water rendered worse, by the intermittent system of supply. All drinking water ought to be drawn direct from the main. Under proper supervision, the waste of water is less on the constant than it is on the intermittent system of supply. These and other advantages have led to the adoption of the constant system in a great majority of British towns."

Table showing the Relation between the General Character of a Water, and the Geological Strata from which it is derived.

Alluvial . . .	Generally more or less impure, and exceedingly variable in quality and in constituents.
Chalk . . .	Clear, wholesome, and sparkling ; generally very pure, and chiefly characterised by the solid matter consisting almost entirely of carbonate of lime.
Limestone and dolomite.	Wholesome and agreeable, but characterised by a larger amount of total solid matter than chalk water, and the presence of a greater quantity of the sulphates of lime and magnesia.
Millstone grit and hard oolite.	Generally very pure ; the solid constituents small, and consisting chiefly of the sulphates and carbonates of lime and magnesia, with a little iron.
Soft sandstone rock, loose sand and gravel, and lias clays.	Very variable in quality—no average criterion can be given.
Granite, metamorphic, trap rock, and clay slate formations.	Generally very pure ; small quantities of solid constituents, mainly carbonate of soda and chloride of sodium, with a little lime and magnesia.

The following is the classification of waters given in the Rivers' Pollution Commission's sixth report :—

WHOLESOME .	Spring. Deep well water. Upland surface water—*i.e.* uncultivated and unmanured land, as hills and mountains.
SUSPICIOUS . .	Stored rain water. Surface water from cultivated land.
DANGEROUS .	River water containing sewage. Shallow well water.

Characteristics of a Good Drinking Water.

1. It should be without taste or smell, and preferably without colour.

2. It should not contain an undue amount of solid constituents, especially when such constituents are salts of lime or magnesia. The amount of solids should not exceed eight grains per gallon, one grain of which should be alone dissipated by heat. In chalk water the solids should not be more than fourteen grains per gallon. Wanklyn, however, holds that unless a water contains more than forty grains of solids per gallon, no exception need be taken to the solids as such.

3. It should be practically free from nitrogenous organic matter, the albuminoid ammonia being less than 0·05 parts per million, and a water should be regarded with suspicion which, along with a considerable quantity of free ammonia, yields ·05 part of albuminoid ammonia per million.

The apparent purification of running streams is due to the following:—(1) Oxidation; (2) Deposition; and (3) Dilution.

But even with these agencies at work, it is impossible to say when a once-polluted stream becomes pure and the water fit to drink. The banks of rivers, if not carefully attended to, may become the sources of disease, due to the deposit of decaying animal matter on them.

Diseases due to Impure Water.

Diarrhœa.—Due probably to the presence of organic matter, chiefly of animal origin. Suspended fine mica scales have also been accredited with the production of this disease.

Dyspepsia, or more properly, certain gastric symptoms to which the popular term dyspepsia is applied, are said to be caused by the use of hard water.

Dysentery.—Several epidemics of this disease have been traced to the use of impure water, especially when impregnated with sewage.

Entozoa, etc., may be conveyed by water, tape-worm ova, the ova of *Distoma hepaticum*, etc., the *Filaria sanguinis hominis*, *Bilharzia hæmatobia*, etc.

Cholera and Typhoid Fever.—The most important water-borne diseases are cholera and typhoid fever. The contamination of the water supply at Hamburg led to the serious outbreak of cholera in that city some years ago. More recently the pollution of the water supply at Maidstone gave rise to a serious outbreak of typhoid fever. Instances of the association of outbreaks of these diseases with polluted water supplies are very numerous.

With regard to *insufficiency* of supply, the prevalence of the summer diarrhœa of infants bears a close connection with absence of rain. In cities and towns the value of heavy rainfall in street-washing, drain-flushing, and so forth is very great. It is an almost invariable experience that the choleraic disease of the summer and autumn months is highest when rainfall is low, and declines to its minimum when frequent, sudden, and heavy, rather than continuous, rainfall occurs. The explanation is that in a fine warm summer the accumulations of dust and dirt, largely unavoidable unless removed by washing, give rise to a filth-laden atmosphere, and the mischief which follows from such a condition. Consequently the full benefit of rain will only be experienced when the fall is heavy enough to exert a cleansing power.

The connection between cleanliness and health is indicated by the table showing the association of rainfall with diminished mortality from choleraic diarrhœa in Liverpool during the last twenty years, six of which were average wet summers, with relatively low mortality, and fourteen were average dry summers, with considerably higher mortality; the extremes being 1891 and 1895:—

[Table

Period.	Average Annual Rainfall, June to September.		Annual Average of Deaths from Zymotic Diarrhœa during the Third Quarter of the Year.
Six years . . .	13·8 inches	Average wet summers	373
Fourteen years .	10·9 inches	Average dry summers	573
Extreme years. Year 1891 .	16 inches	Wet summer	203
Extreme years. Year 1895 .	7·7 inches	Dry summer	819
Year 1901 . .	8·4 inches	Dry summer	1067

The difference in rainfall in the two years 1891 and 1895 means that upwards of 900 millions of gallons of water were distributed to the city in the season of low mortality, which were absent in the year of high mortality. The distribution resulting in thorough washing of all exposed surfaces.

Examination of Water.

Hard and Soft Water.—Natural waters contain varying proportions of lime and other mineral salts, and on the amount of these constituents depends the relative *hardness* or *softness* of water. The hardness of water is mainly due to the presence of the salts of lime and magnesia. When these are present in excessive quantity, the water is said to be "hard"; and when heated, incrustations are formed on the inside of vessels. A great destruction of soap also occurs when such water is used for washing clothes and other purposes. A "soft water" is one below six degrees of hardness, and "each degree of hardness destroys $2\frac{1}{2}$ ounces of soap in each 100 gallons of water used for washing. Soft water is commercially of more value than hard water in proportion to the worth of 5 ounces of soap to each 200 gallons for each degree of hardness." In brewing, however, hard water is an advantage, and the per-

manent hardness due to sulphate of lime may even reach to 28 or 30 degrees without detriment to the water.

Some hard waters are softened by boiling; others are not. The hardness of water removed on boiling is due mainly to the presence of the *carbonates of lime and magnesia;* whilst the water, the hardness of which is but slightly, if at all, affected, contains *sulphate of lime.* Chalk waters are most influenced by boiling, as the carbonate of lime is held in solution by the excess of carbonic acid present. When a chalk water is boiled, the carbonic acid is expelled, and the carbonate of lime is to a great extent precipitated. The hardness due to carbonate of lime is termed "temporary," as it can be thus removed; that due to the sulphates of lime and magnesia is termed "permanent," as it is not removable by boiling. It is always desirable to know to which of the above the "hardness of water" is due, as, in excessive cases, a knowledge of the cause would determine whether the water might be rendered fit for domestic purposes.

Degree of Hardness.—By this term we mean that a given volume of water decomposes a certain number of c.c. of the standard soap test. Thus, "fifteen degrees of hardness" means that fifteen c.c. of the soap solution have been used. Each c.c. = one degree of hardness.

In Clark's estimation of "hardness" each degree of hardness corresponds to one grain of soap-destroying salts in a gallon of water, and does not refer to the quantity of soap which a gallon of the water will destroy.

A *rough* means of judging of the relative degree of hardness of any sample of water consists in placing a small quantity in a test glass, and adding to it a few drops of a standard solution of soap in alcohol, when a white turbidity will make its appearance, depending in degree on the hardness of the water.

In order to estimate the exact degree of hardness in any given sample of water, accurate standard solutions are needed. These are prepared as follows:—As a basis, a solution of lime is made by dissolving 0·2 gramme (3·088 grs.) of Iceland spar in dilute hydrochloric acid, evaporating to get rid of the free acid, and finally dissolving the calcic chloride in distilled water, and diluting to one litre. A solution is then made by rubbing together in a mortar 150 parts of lead plaster (Emplast. Plumbi) with 40 parts of dry potassium carbonate. The mixture is then treated with methylated alcohol, thrown into a

filter, and washed several times with fresh portions of methylated spirit. The solution thus obtained is diluted with a mixture of one volume of distilled water and two volumes of methylated alcohol, until exactly 14·25 c.c. (220 grs.) are required to form a permanent lather with 50 c.c. (772 grs.) of the standard calcic chloride solution.

This soap solution is used for taking the degree of hardness in a water as follows :—50 c.c. of the water are placed in an eight-ounce stoppered bottle, shaken briskly for a few seconds, and the air then sucked out (to remove carbonic acid). The standard soap solution is then run in in small quantities at a time, shaking the bottle after each addition, until a lather is formed permanent all over the surface of the water for five minutes. By noting how much soap solution has been used, and referring to a table, the degree of hardness is determined. Each "degree" represents a hardness equal to one grain of carbonate or sulphate of lime per gallon in soap-destroying power.

When waters have a hardness of more than sixteen degrees, the water must be diluted with distilled water before making an estimation. (See Wanklyn and Chapman's *Water Analysis.*)

Nature and Origin of Deposits in Boilers.

When water containing a quantity of earthy salts is concentrated, not only is the carbonate of lime deposited in the way just described, but as the solution becomes more and more concentrated, the other earthy constituents present are more or less completely thrown down. Thus, we find that a large deposit occurs in steam boilers in which ordinary water is used, and much inconvenience frequently arises from this source, especially when the deposit assumes a compact form, from the slowness of its deposition. The bursting of boilers may often be due to this deposit. Water boils more readily in a vessel with rough sides than in one in which the sides are smooth and polished, and in these rugosities a large quantity of air is confined. The sudden expansion of the contained air, and rapid vaporisation of the water, often causes a bursting of the boiler before the temperature has reached the boiling-point. The accidents due to this cause often occur before the machine has begun to work, and when the manometer shows a pressure

but a little above that of the atmosphere. Sometimes a crack may occur in the incrustation, allowing the water to come in contact with the almost red-hot iron of the boiler. A sudden formation of steam results, which may destroy the boiler. Many schemes, both chemical and mechanical, have been proposed to prevent the deposit in boilers ; but the treatment must vary with the character of the water. If the incrustation cannot by any means be *prevented*, a plan frequently adopted is to introduce some light powdered substance into the boiler with the water. This acts mechanically by keeping up the free generation of steam ; and the water being thus kept in constant and violent motion, the earthy salts are precipitated in the form of a fine powder, which is periodically removed by "blowing out," as it is termed. The chemical scheme which appeared most likely to prove successful, consisted in the addition of chloride of ammonium to the water in the boiler. A conversion of the carbonates of lime and magnesia into soluble chlorides is the result, while the carbonic acid passes off with the ammonia as carbonate in the steam. The great objection to this method is, that carbonate of ammonia acts on brass or copper fittings, and this has precluded the employment of the process, except under special conditions.

There is a process, known as *Clark's Process*, in use for the prevention of boiler deposits, and for the softening of water for domestic purposes. This process is, however, only adapted to the treatment of chalk waters to get rid of the "temporary hardness," and for these it is exceedingly useful. It is carried out in the following manner :—The water, collected in large tanks, is treated with a sufficiency of lime water to neutralise the free carbonic acid present. As the carbonate of lime present in the original water is only retained in solution by the excess of carbonic acid, it follows that, if this be removed, the carbonate of lime will be precipitated. The lime water acts, therefore, by neutralising the carbonic acid, forming with it insoluble carbonate of lime, which is thus precipitated together with the carbonate of lime previously dissolved in the water. By this means, not only is the lime almost entirely removed, but a certain degree of organic purification takes place by the precipitated lime carrying down with it a considerable amount of the organic matter present.

The above process is now in use on a large scale at several

paper mills, and at other manufactories. It can also be carried out in private houses. The Kent Companies' water, the purest of the London supplies, obtained from deep wells in the chalk, was formerly entirely treated by Clark's process before it was supplied to the public. The process effects an immense saving in many manufacturing undertakings, as well as an economy in soap.

Origin of the Sulphuretted Hydrogen of Sulphurous Waters.

The presence of sulphuretted hydrogen in water is generally held to arise from the deoxidising influence of decaying organic matter on the various sulphates present; the oxygen of the sulphuric acid unites with the carbon of the organic matter to form carbonic acid, while the sulphur combines with the hydrogen to form sulphuretted hydrogen.

Action of Water on Lead.

Natural waters are found to act in a variety of ways on lead; and as drinking water generally meets with lead either during its conveyance to the consumer through pipes of that metal, or by being stored in leaden cisterns, it becomes of the utmost importance that the conditions under which natural waters become charged with lead should be known. There is one broad fact which may be taken in connection with this subject: that hard waters have, as a rule, very little, if any, action on lead, while soft waters dissolve more or less of that metal. The impunity with which hard waters may be stored in leaden cisterns depends on the fact that a coating of insoluble lead salts is soon formed on the surface of the metal, which protects the lead from the further action of the water. The salt having the most protective action is the sulphate; and as ordinary hard waters, as a rule, contain earthy sulphates, we are able to use such waters with impunity. Silicates also exert a protective effect. On the other hand, as soft waters have no such protective properties, they become more or less charged with lead—the oxygen dissolved in the water forming oxide of lead, which, soluble in the water, causes contamination. Waters containing nitrates or nitrites

in solution or excess of carbonic acid are especially to be avoided, as such waters exercise a powerfully solvent action on lead; and these salts have been known to corrode that metal to such an extent as to eat holes in the cistern in which the water was stored. In soft upland waters, the presence of humic or ulmic acids, as also bacterial action, have been suggested as acting upon lead. Filtration through silicate has been adopted as a remedial measure, and the use of tin-lined or glass-lined pipes, or pipes coated with Angus Smith's varnish, advocated. Barff's rustless iron may be employed. In cases of doubt the water should be run off for a few minutes, so as to clean the pipes, and lead cisterns must be avoided.

Lead is a metal which fortunately admits of easy detection, even when in minute quantities. If present to any extent, it can be detected by taking a portion of the water in a tall glass jar and adding some sulphuretted hydrogen water, when, if lead be present, a brown colour is observable, which may be rendered more apparent if the jar containing the water be held over a piece of clean white paper. When present in minute quantities, and more especially if it be desired to make a quantitative estimation of the amount present, some of the water should be evaporated to a small bulk, and then acidified with hydrochloric acid. On the addition of sulphuretted hydrogen water, the whole of the lead will be thrown down as the sulphide.

If a solution containing a known quantity of a salt of lead be treated with sulphuretted hydrogen, and the colour so produced compared with that of the suspected water, to which sulphuretted hydrogen has also been added, a quantitative estimate of the lead present may be made.

Practical Test of the Action of Water on Lead.—Take a beaker containing eight ounces of the water to be examined, and place in it a piece of plumber's cistern "six-pound lead," 4 inches by 1 inch. Each square inch of the lead sheet is thus acted upon by one ounce of water. The water may be examined daily, the colour produced on the addition of sulphuretted hydrogen compared with a standard solution of lead. Wanklyn gives the following process:—Take 70 c.c. of the water, place them in a white porcelain dish, and stir with a glass rod dipped in sulphide of ammonium. If the slight coloration formed be not absolutely destroyed on acidification

with hydrochloric acid, the water should be condemned as contaminated with metallic impurity—either copper or lead. Lead poisoning may result from so small a quantity as one-ninth of a grain per gallon.

Different Forms under which Nitrogen is found in Water.

Nitrogen is found in water under the following forms :—(*a*) Ammonia. (*b*) As Nitrates and Nitrites. (*c*) As Nitrogenous Organic Matter.

Nitrogen under one or other of the above forms is found in small quantities in all waters. Some of the chalk waters invariably contain nitrates and nitrites, probably due to fossil organic remains. The sources whence the nitrogen in water is derived vary. Rain water, especially when collected near towns, invariably contains small quantities of nitrogen in the form of ammonia, dissolved during the passage of the rain through the air.

The sources of nitrogenous organic impurities are chiefly of animal origin, due to infiltration from cesspools and church-yards.

Although the mere presence of nitrates and nitrites in a drinking water cannot be looked upon as affording conclusive proof of a "previous sewage contamination," it should always be regarded as a suspicious circumstance, and should lead to a search for possible sources of contamination (Corfield).

Estimation of Nitrates and Nitrites.

(*Wanklyn and Chapman's Method.*)

This is a modification of Schultze's aluminium process, and is an exceedingly accurate test. About a pint of the water to be tested is placed in a retort, and a definite quantity of strong, pure caustic soda solution added, and the whole distilled till all the ammonia has been driven off. The contents of the retort are now left to cool, and a piece of thin sheet aluminium introduced, and allowed to remain for four or five hours. Hydrogen is evolved from the metallic aluminium, which, being in the nascent state, unites with the nitrogen of the nitrates and nitrites present to form ammonia. After the action has

ceased, the contents of the retort are again distilled, and the ammonia given off estimated by Nessler's test. The ammonia thus obtained is an index of the amount of the nitrates and nitrites present.

The Nessler Test.

This reagent is prepared by dissolving 50 grammes (772·0 grains) of potassium iodide in a small quantity of distilled water, subsequently adding a cold saturated solution of corrosive sublimate until the precipitate of mercuric iodide ceases to be dissolved. 200 grammes (3088 grains) of caustic potash in strong aqueous solution is then added to the above, and the whole made up by the addition of water to one litre. A little more of the corrosive sublimate is then added, and the whole allowed to settle. The clear liquid is then decanted and preserved in closely stoppered bottles in a dark, cool place, until required for use. The addition of the last quantity of corrosive sublimate solution is requisite in order to impart the necessary sensitiveness to the test.

The Nessler test is based on the fact that, when a saturated solution of iodide of mercury in iodide of potassium, rendered strongly alkaline by the addition of caustic potash, is added to water containing ammonia, various shades of a brown colour are produced. By comparing these shades of colour with those produced in standard solutions of ammonia, the amount of ammonia present in the sample of water under examination may be estimated. It is necessary that the ammonia solution be very dilute; for, if too strong, the reagent will be either precipitated, or the delicate shades of colour, so necessary for the success of the test, destroyed by the intense dark colour produced. In testing ordinary water, it is necessary to concentrate the water by distillation; but in the case of sewage, which is always rich in that substance, pure distilled water, free from ammonia, must be added to the distillate till the proper degree of dilution is obtained. In this process all apparatus used must be scrupulously free from ammonia.

Quantitative Examination of Potable Water.

The ordinary quantitative examination of water involves the estimation of the following points:—Total solid matter,

hardness (temporary and permanent), chlorine, ready-formed ammonia, nitrogen existing in organic matter, or "albuminoid ammonia," and nitrogen in the form of nitrates and nitrites.

Determination of the Total Solid Matter.—For this purpose a measured quantity of the water is evaporated on the water-bath in a platinum basin to dryness, and the weight of the perfectly dry residue then ascertained. It is best to ascertain the exact weight of the perfectly clean platinum basin, to then introduce the water to be evaporated, and, after the evaporation, to transfer the basin and its contents to an air-bath heated to about 250° F., by which the water residue is thoroughly dried. The basin may then be withdrawn from the air-bath, rapidly cooled by being placed on a massive piece of iron, and weighed. The increase in weight above that of the platinum basin will give the solid matter. It is advisable to replace the basin containing the water residue in the air-bath for a short time after the first weighing, and to subsequently re-weigh, in order to be perfectly sure of the absolute dryness of the residue. Any quantity of water may be taken for evaporation, but it is not advisable to employ too large a quantity, as the time occupied is considerably increased, and there is more danger of error from the settlement of dust. About 2000 grains is a convenient quantity, if the operator is in possession of an accurate balance, the above quantity being $\frac{1}{35}$ of a gallon. If 3500 grains be taken, the result is multiplied by 20, this quantity being $\frac{1}{20}$ of a gallon. After weighing the perfectly dry water residue, the contents of the platinum basin may be gently ignited, and any blackening noticed as an indication of the presence of organic matter; the smell evolved at the same time will afford a rough criterion as to whether the organic matter is of animal or of vegetable origin. The actual amount of the "loss on ignition" may be noted, but is not of much distinctive value.

Examination of the Water Residue.—The unignited residue is best employed for this purpose. A small quantity of distilled water is placed in the basin, and the reaction of the liquid to red litmus paper noticed, when an alkaline reaction will betray the presence of alkalies (potash or soda, generally as carbonate). A few drops of hydrochloric acid are then added, when any effervescence indicates the presence of carbonates.

The liquid may then be tried for sulphates, for lime, and for magnesia in the usual way.

Determination of Chlorine.—This is generally performed volumetrically by means of a standard solution of silver nitrate, using potassium chromate as an indicator. The method is founded on the affinity which silver possesses for chlorine over that which it has for chromic acid, and on the distinctive colours of the compound formed in each case. In using the process, the silver nitrate solution is dropped into a measured quantity of the water, tinted a faint yellow by the previous addition of a few drops of a solution of potassium chromate. As long as any chlorides are present in the water, white silver chloride is formed, but the moment the amount of soluble chlorides is exhausted, the liquid acquires a reddish tint from the formation of red silver chromate.

The standard solution of silver nitrate is prepared by dissolving 4·79 grammes of the pure salt in one litre of distilled water. One cubic centimetre of this solution equals one milligramme of chlorine, or every grain measure equals ·001 grain chlorine.

The water should be placed in a white porcelain basin during the examination, and the condition for accuracy is that the water must be neutral, or faintly alkaline.

Nitrogen in the Form of Ammonia, and as Nitrogenous Organic Matter.—For the purpose of estimating the amount of nitrogen in the above-mentioned forms, the method of Wanklyn and Chapman is that generally adopted. The process is dependent on the use of the Nessler test in the estimation of ammonia, and on the fact that nitrogenous organic matter yields a definite quantity of its nitrogen, in the form of ammonia, on distillation with an alkaline solution of potassium permanganate.

The following are the methods for the estimation of the free ammonia and "albuminoid ammonia":—

1. Free Ammonia.—A pint of the water to be examined is placed in a scrupulously clean stoppered glass retort, connected with a Liebig's condenser. A small quantity of a saturated solution of carbonate of soda is added to the contents of the retort, and the whole carefully distilled. The distillation is continued until 150 c.c. have passed over, and are collected in three successive pure white glass tubes, an inch and a quarter in diameter, and at least a foot long, each holding 50 c.c. of the distillate, which contains the ready-formed ammonia present in the

water. A measured quantity (2 c.c.) of Nessler reagent is added to the contents of each tube, and the colour produced imitated by adding the reagent to a standard solution of ammonia in a similar glass tube. Several trials are made, till the shade of colour in both cylinders is alike, when the amount of standard ammonia used will give the quantity of this substance in the suspected water. The standard ammonia solution is made by dissolving 0·0315 gramme (0·48636 grain) of ammonia chloride in a litre of water. Each c.c. of the solution contains ·0001 gramme of ammonia, or each grain measure equals ·0001 grain.

2. "ALBUMINOID AMMONIA."—A certain proportion of a strongly alkaline solution of permanganate of potash, of known strength, is now added to the contents of the retort, and the process of distillation resumed. The distillation is stopped as soon as the last portions of the distillate cease to give the reactions of ammonia. The distillate contains all the ammonia, which may now be tested as before. The quantity so obtained is a measure of the amount of nitrogenous organic matter present in the original water.

The alkaline solution of potassium permanganate is made by dissolving 8 grammes (123·5 grains) of the permanganate and 200 grammes (3088 grains) of potash in a litre of water. The quantity of the solution used is about a tenth part of the water originally taken for analysis. The ammonia is estimated by Nessler in the manner already described.

Gases dissolved in Water and their Estimation.

The gases are oxygen, nitrogen, carbonic acid, sulphuretted hydrogen, and, in marsh water, marsh gas. The first three may be estimated by using a mercurial trough with a graduated glass tube filled with mercury and inverted in the trough. The water is then gently boiled in a flask for an hour, and the gases passed into the tube. With the aid of a pipette a solution of caustic potash is passed up the tube to absorb CO_2. When no further decrease of volume, read off CO_2. Then in the same way pass up a solution of pyrogallic acid to absorb O, and read off volume. Nitrogen alone now remains, and its volume is read. Sulphuretted hydrogen may be detected by its smell or the addition of a solution of acetate of lead. In the above process the CO_2 is increased, due to decomposition by heat of the carbonates, and the O and N cannot all be obtained by this method.

Frankland and Armstrong's Method.

Frankland and Armstrong's process consists in submitting to organic analysis, by combustion with oxide of copper in a

combustion tube, the residue obtained by evaporating the water under examination to dryness. The gases—nitrogen and carbonic acid—liberated during the combustion are collected in a graduated tube. The carbonic acid is withdrawn by the aid of caustic potash, leaving the nitrogen, when its volume can be read off. Previous to evaporation any nitrates or nitrites are destroyed by the addition of sulphurous acid to the water. The above process gives the amount of nitrogen present in the form of ammonia and organic nitrogenous matter.

The amount of nitrogen present as nitrates and nitrites is estimated by treating the residue of another portion of the water with strong sulphuric acid in a graduated tube standing over mercury. On agitating the tube, the whole of the nitrogen present in the form of nitrates and nitrites is liberated as nitric oxide, the volume of which is read off and halved for the amount of nitrogen. As the evolution of hydrochloric acid gas, the result of the action of the sulphuric acid on any chloride present, would interfere with the result, all the chlorides are destroyed by the addition of sulphate of silver previous to the addition of the sulphuric acid.

The Collection of Samples.

Rules with regard to the collection of samples of water:—

1. Collect sample in a scrupulously clean glass-stoppered "Winchester quart," which holds about half a gallon. Tie stopper down with a piece of clean calico or linen.
2. Keep water in a cool, dark place, and, if possible, proceed to its examination within forty-eight hours after collection.
3. In collecting samples of town water, draw direct from street mains or at jets at cab-stands, first allowing some of the water to run away, so as to clean the pipe.
4. In collecting from a pond or river, be careful not to allow any surface scum to enter. Immerse the stoppered bottle, and then remove the stopper. Collect water in the middle of a stream, in the case of a river. Avoid outlets of sewers and feeders.
5. Make a note of localities of collection, late rains, or droughts.
6. Rinse out bottle with some of the water to be examined, and do not quite fill it.

Qualitative Examination of Water.

In many cases a qualitative examination of a specimen of water will afford a sufficient criterion of its suitability for

domestic purposes: in any case, however, where the character of the sample is doubtful, a quantitative examination should be made.

The following Table will afford the necessary information as to the method of conducting a preliminary examination of any specimen of water:—

TABLE FOR THE QUALITATIVE EXAMINATION OF WATER.

Hardness . .	To a small quantity of the water in a large test tube add a little "Soap test," and shake, when the degree of turbidity produced will afford a rough indication of the degree of hardness.
Chlorine . .	Acidify a little of the water with nitric acid, and add a few drops of silver nitrate solution. Four grains of sodium chloride per gallon gives a slight turbidity, 10 grains a slight precipitate, and 20 grains a considerable precipitate.
Organic matter, or recent sewage contamination	Add to a few ounces of the water sufficient dilute solution of potassium permanganate to produce a faint pink colour. The solution will gradually become decolourised, the rapidity depending on the amount and characters of the organic matter present. Ferrous salts, nitrites, and H_2S must be absent.
Sulphates . .	Acidify with hydrochloric acid, and add a few drops of barium chloride solution—a white turbidity will be produced, varying in amount with the quantity of sulphates present.
Free ammonia .	Add a few drops of Nessler test, and note the degree of brown or yellowish coloration produced.
Nitrates . .	Mix a little of the water with twice its bulk of pure sulphuric acid, then add a drop of a solution of pyrogallic acid. A pink-blue colour, changing to brown, indicates nitrates.
Nitrites. . .	Acidify water with sulphuric acid, and add a little *pure* potassium iodide, followed by a little freshly-prepared starch solution. A blue tint indicates the presence of nitrites.
Lead, copper, or iron	Acidify some of the water with hydrochloric acid, and add a little sulphuretted hydrogen water. Any brown coloration indicates lead or copper. Or the water may be stirred with a glass rod dipped in ammonium sulphide, and colour noticed. Iron gives the same coloration, but the colour disappears on the addition of HCl.

Interpretation of Results.

Hardness.—An excessive amount is undesirable.

Chlorine. Good drinking water should contain very little chlorine, unless the presence of it be explained by the geological character of the formation from which the water is derived, or the proximity of the source of supply to the sea. Chlorine in abnormal quantity (except under the circumstances named) may indicate sewage contamination; and, if associated with organic matter and free ammonia, the contamination is *recent*, and may be dangerous—if with nitrates and nitrites, the danger is less.

Organic Matter.—This should not be present in any quantity, and, except where obviously of vegetable origin, as in the case of peaty waters, should be regarded with suspicion—more especially if associated with chlorine and free ammonia in abnormal quantity.

Nitrates and Nitrites.—These should be regarded with suspicion, except in the case of deep well waters and those derived from the chalk. In shallow well waters the presence of nitrates and nitrites is invariably to be regarded with distrust, as proving an existing contamination which may be liable to assume a dangerous character. In this case chlorides will also be found. The presence of nitrites points to a more recent contamination than the presence of nitrates. Nitrates are harmless in themselves, but their presence points to possible danger.

Sulphates.—If unassociated with any special geological features which would account for the presence of an unusually large amount of sulphates, their existence in excessive quantity, taken in conjunction with chlorides, organic matter, ammonia, etc., is corroborative evidence of sewage contamination.

[TABLE

Synopsis of Chemical Examination of Water.

Data.	Good.	Doubtful.	Bad.
Total solids (grs. per gall.)	Under 10	20 to 40	40 +
Loss on ignition . .	Slight. No blackening	Much blackening. 2·0 loss	Much blackening and fumes, and smell of burnt horn
Chlorine (parts per million)	Under 15	15 to 50	100
Nitrites and nitrates	Nil Trace	Present Marked	Large
Ammonia—			
Free . . .	·02	·05	Over 0·10
Albuminoid . .	·05	·10	Over 0·15
Sulphides . . .	Nil	Nil	Present
Metals . . .	Nil	Trace of iron	Iron, lead, etc.
Physical characters .	Clear Colourless Palatable No smell	Turbid Yellowish Taste bad Any	Turbid Yellowish Taste bad Any
Microscope . .	Mineral forms	Debris (organic)	Fungus, scales, ova

Bacteriological Examination.

The bacteriological examination of water is of great importance. As a routine practice the water supplied to cities should be examined frequently, both at its sources of supply and before final delivery into the mains. In taking the samples every precaution must be observed to prevent extraneous contamination; samples should be collected in sterilised bottles, and if not examined at once, they should be kept in a refrigerating chamber. In all cases the number of bacteria per c.c. should be noted, and these should be below 100 (Koch's standard). The *Bacillus coli* and *B. enteritidis* sporogenes should be looked for ; the sample is passed through a sterilised Chamberland filter, the micro-organisms are brushed off into the sterile filtrate, and cultivated.

CHAPTER V.

AIR, VENTILATION, AND WARMING.

The atmosphere is the gaseous envelope which surrounds this earth. Its height has been estimated at from 30 to 40 miles, but from the observations of meteorites a height of 200 miles has been assumed.

The atmosphere consists of a mechanical mixture of two gases — oxygen and nitrogen. This is shown from the following: —

1. The amounts of oxygen and nitrogen in the atmosphere are not in their combining proportions.
2. When mixed in the proportions found in the air, no contraction in volume or evolution of heat is noticed.
3. Water takes up unequal portions of the two gases, according to the law of absorption of gases in liquids.

The oxygen is the active agent in supporting animal life and promoting the combustion of bodies; the nitrogen acts simply as a diluent, and modifies the activity of the oxygen. The proportion of oxygen to nitrogen is as 1 to 4; or by volume, nitrogen 79·19, oxygen 20·81; by weight, 76·90 and 23·01 respectively. The air collected by Martins on the Faulhorn, at a height of 8226 French feet, had not less oxygen than the air of Paris. More recent investigations have shown that often the oxygen at great elevations is less than at lower levels. This has been ascribed not to diminution of oxygen in the upper levels, but to an increase in the lower from the fixation of carbon and liberation of oxygen by plants. On the other hand, it has been found that CO_2 increases with height; and Smith suggests that the organic substances floating in the air become oxidised; hence the diminution of oxygen with

increase of CO_2 as just stated. Hence, mountain air appears to contain little or no organic matter, and more CO_2 and less oxygen than lowland air. It has been proposed to take the percentage of oxygen as a test of purity, "very bad air beginning at 20·6" (SMITH).

The amount of carbonic acid varies from ·02 to ·05 per cent, or ·2 to ·5 per 1000; its presence is due to the respiration of animals, to gases from the interior of the earth in districts of extinct volcanoes and thermal springs, and the decomposition of the small portion of carburetted hydrogen existing in the air by the electric discharges of clouds (HUMBOLDT). To these we may add the combustion of carbonised materials. The air collected above the ocean shows a small variation in carbonic acid between day and night, the proportion being 5·4 for the former, and 3·3 for the latter, in 10,000 volumes of air; this being probably due to the increase of the coefficients of absorption with decrease in temperature during the night.

Owing to the escape of the products of combustion, of respiration, and the decay of animal and vegetable substances, the atmosphere also contains aqueous vapour, carbonic acid, ammonia, organic matter, salts of sodium, etc. Recent researches indicate that about 1 per cent of what was regarded as nitrogen is an elementary gas called *argon*.

Ozone, an allotropic form of oxygen, appears from modern researches to be condensed oxygen in which three volumes are condensed into two, one of the volumes being, however, in a different polar condition from the other two $\left(\overset{-}{0}\overset{+}{0}\overset{-}{0}\right)$. It possesses powerful chemical activity as an oxidising agent, and in this is superior to oxygen. It may be developed artificially by passing electric discharges through air or damp oxygen; by the slow oxidation, *eremacausis*, of phosphorus in air; by the electrolysis of water acidulated with sulphuric acid—and by the action of three parts of strong sulphuric acid on two parts of potassium permanganate aided by heat. Its chief source is atmospheric electricity, and it is the cause of the supposed sulphurous smell said to accompany thunderstorms.

Ozone has the property of bluing starch paper treated with iodide of potassium, by setting free the iodine. This change may also be effected by chlorine or any nitrous acid present in the atmosphere. A better test—Houzeau's ozonometer—is the bluing of litmus paper slightly reddened and impregnated with

iodide of potassium; ammonia being the only gas which has a similar reaction. But this source of error may be obviated by noticing that reddened litmus paper, not impregnated by the iodide, is blued by ammonia, but not by ozone. Its presence may be roughly estimated by exposing strips of paper prepared as above for a given time, and noting depth of colour produced. Standard shades of colour may be used for comparison. Ozone is said by Schönbein, its discoverer, to destroy organic matter floating about in the air of a room. On the air-passages it causes severe irritation, and its excess in the air has been suggested as a cause of influenza and other respiratory troubles.

Air is a mechanical mixture, and of practically uniform composition, from whatever natural source it be derived; the quantity of free carbonic acid is subject to slight fluctuations; in enclosed places, and in the vicinity of decomposing matter, impurities may be found, but apart from these, the uniformity of the mixture is maintained by varying temperatures and consequent winds and currents, and by the natural law of gases to diffuse; thus, if a heavy gas and a light gas are placed together in a vessel, the heavy gas below and the light above, they slowly mix even when left at rest; but, when once mixed, they show no tendency to separate; and however long the mixture is kept, the mixture at the top will be found to have the same composition as that at the bottom. The rate of diffusion of gases is inversely as the square roots of their densities.

Impurities of Air and their Sources.

An immense number and variety of particles, organic and inorganic, of vapours and gases, pass into the atmosphere; amongst the kinds of dust are mineral matters, algæ, pollen, dried particles of debris from road and midden refuse, manure, soot, and products, gaseous and particulate, from factories and industrial works of all kinds. Microbes are found, sometimes in excessive numbers, and the purport of their presence is still the subject of careful investigation; moisture, nutritive material, and a certain degree of warmth are essential to their development; their numbers vary enormously in different localities, and they also vary, though to a much less extent, at different seasons; in the external air they appear to increase largely during the summer and autumn months in temperate latitudes;

within-doors, in closed-in places, and in overcrowded rooms the greatest increase is in the winter, when the numbers are enormously increased, owing, no doubt, to defective ventilation at this season. As a mean of six years' observation, Miquel found, during February, 155 per cubic metre of air at Montsouris, against 2480 in the Rue de Rivoli; in July, 740 at Montsouris, against 5205 in the Rue de Rivoli. As other examples he quotes the practical freedom from microbes of the high mountains, as against 79,000 per cubic metre found in the Hôpital Hôtel Dieu, Paris.

It would appear that in the open air bacteria are diluted and destroyed, whilst in any case the numbers of disease-producing microbes are relatively few, excepting when local conditions are such as favour their development.

The following are important sources of contamination :—

(a) *Products of Combustion in Warming and Lighting.*

Impurities arising from the products of combustion are important. *Coal* is the material most commonly used as fuel, and the most common source of prejudice to health in connection with it results from smoke. The products of the combustion of coal are carbonic acid and carbonic oxide, in variable quantity as the processes of combustion are incomplete, there being very little with complete combustion; about 1 per cent of the coal is reckoned to pass into the air as soot or smoke, but in wasteful misuse of coal, accompanied with excessive and unnecessary smoke, probably a much larger percentage is given off. Other impurities in small quantities resulting from the burning of coal are sulphides of carbon and ammonium, and occasionally other compounds of sulphur, and water. The impurities resulting from the combustion of coke and peat resemble those of coal; wood, however, gives off more water and less of the sulphur compounds.

The products of the combustion of fuels pass directly into the external air, becoming freely diluted and dispersed.

Artificial lighting gives rise to impurities important from the fact that it is seldom that means are provided to convey them into the external air. Moreover, in the case of *gaseous* illuminants, danger may arise from leakage into occupied rooms from defective pipes or fittings; this is especially to be feared

in the case of water gas, which contains a large proportion of the excessively poisonous gas, carbonic oxide. Ordinary coal gas is a mixture produced by the destructive distillation of coal, which is heated in retorts without access of air; water gas is made by passing steam over the heated fuel in a fire-brick chamber, and by subsequently enriching it with hydrocarbons; it is much cheaper and easier of manufacture than coal gas. The composition by volume of ordinary coal gas, and of a mixture of equal quantities of coal gas and carburetted water gas, may be given as follows:—

	Coal Gas.	Fifty per cent Mixture of Coal Gas and Carburetted Water Gas.
Carbonic acid	0·7	0·2
Heavy hydrocarbons	6·2	8·9
Oxygen	0·2	0·0
Hydrogen	46·0	43·5
Methane	36·4	26·9
Nitrogen	4·9	2·2
Carbonic oxide	5·6	18·3
	100·0	100·0

The great excess of the very poisonous gas, carbonic oxide, in water gas, and proportionately in its mixtures, is evident.

Various kinds of *oil* are used as illuminants; paraffin is the commonest, and consists of 86 per cent of carbon and 14 per cent of hydrogen; its products of combustion are carbonic acid and water, an ordinary lamp giving off about 0·4 of a cubic foot of carbonic acid per hour.

All of the illuminants already referred to have the effect in varying degrees of raising the temperature, abstracting oxygen from the air, and adding carbonic acid, moisture, and, to a small degree, compounds of ammonia, carbonic oxide, and particles of soot. Dr. Odling states that, for equal illuminating power, candles yield a larger amount of impurity to the air than gas, and that two candles have the same effect on the air as one man. A candle of six to the pound burns about 170 grains per hour. The combustion of three cubic feet of gas per hour

renders 3600 cubic feet of air impure. A burner of this description vitiates more air than three adult persons.

Of recent years a very largely increased use is being made of *electricity* for illuminating purposes. Without taking other advantages into consideration, the hygienic superiority of this method over the others is very great. The incandescent carbon or platinum thread is enclosed in a small hermetically sealed globe; there is, in consequence, no possibility of any contamination of the air, and the raising of the temperature by this form of lamp is too small to be of importance. The arc light is not enclosed, and is said to cause the formation of nitric acid, but even if this be the case, the amount of impurity is very much less than that from other illuminants, especially gas. Electricity is extensively employed in lighting public and private buildings and offices, hospitals, dwellings, etc., and there is no illuminant so well adapted to the requirements of inhabited rooms when artificial light is necessary.

(*b*) *Emanations from Sewers and Drains.*

The gaseous contents of sewers and drains are of very variable composition. If the sewer is properly constructed, well ventilated, and adequately flushed, the air in it will not vary greatly from that outside; it is in proportion to the neglect of these essentials that sewer gas becomes offensive and injurious; it is when the sewer is allowed to become a sewer of deposit—an elongated cesspool, in fact—that mischief from stagnating and decomposing sewage results. In these cases there is an increase in the amount of carbonic acid, the oxygen is lessened, fœtid organic vapours and particles collect, as well as varying quantities of marsh gas, sulphide of ammonium, and sulphuretted hydrogen. In closed and sealed cesspools the air is highly impure from these causes. Various micro-organisms, bacilli, and moulds are found in sewer air; these, however, are relatively few, probably because they adhere to the moist surface of the sewer. The effect of breathing the air of rooms to which emanations from sewers and drains find access is distinctly prejudicial, especially so in the case of children; general loss of health, pallor, languor, loss of appetite, and diarrhœa, headache, and perhaps some degree of feverishness, usually ensue, and indicate that the aeration of the blood is not being properly

carried out; sore throat is not infrequently associated with the inhalation of sewage emanations. Children are more susceptible than adults; indeed, amongst men working in sewers of good ventilation it is rare to find illness directly traceable to their occupation. Much depends upon the degree of dilution of the sewer gas; cases of extreme and even fatal illness have been associated with the opening of sewers and cesspools which had long been closed, the mischief apparently resulting from the generation of deleterious gases. An atmosphere contaminated with sewer gas, and passing directly into dwellings, will aggravate any form of illness which may exist there, and will always delay convalescence. There appears to be very little doubt that one of the many ways by which the specific poisons of typhoid fever and of diphtheria may find access to the body, is by means of emanations from sewage, either directly by inhalation, or indirectly by pollution of water or food. It must be carefully remembered that the lowered constitution consequent upon breathing sewage emanations predisposes the body to the reception of the poison of zymotic disease, as well as to more severe attacks of the ordinary forms of sickness. Milk and other perishable foods readily decompose if exposed to sewer gas.

(c) *Effects of Respiration.*

The commonest and most important impurities in the air of occupied rooms are those associated with respiration; indeed, from the point of view affecting general hygiene, the changes in the air brought about by respiration and emanations from the skin are to be regarded as those which most tend to prejudice health. The alterations in the gaseous constituents produced in this manner are very marked; the oxygen is considerably reduced, the proportion of carbonic acid is immensely increased, and there is a trifling change in the proportion of nitrogen; the change is as follows:—

	Ordinary Air, per cent.	Expired Air, per cent.
Oxygen	20·96	16·40
Nitrogen	79·00	79·19
Carbon dioxide	0·04	4·41

But other very important changes take place besides these; the expired air is warmer than before inhalation, the amount of watery vapour is increased, and it contains certain organic matters of unknown nature. It will be remembered that by the law of diffusion of gases the atmosphere of occupied rooms, so far as the gases are concerned, is maintained at the normal unless ventilation is absolutely interfered with, and if a window be opened the excess of carbonic acid will not accumulate, whilst the abstracted oxygen will be constantly replaced; but diffusion in this sense does not affect either the watery vapour or the organic matter, neither of which can be got rid of except by an adequate ventilation. The actual amount of watery vapour given off in twenty-four hours from the skin and lungs of each individual varies with the temperature and humidity of the surrounding atmosphere, as well as with the amount of work being done; 10 ounces of water from the lungs and 20 ounces from the skin may be regarded as the average amount under average conditions.

"Five hundred children assembled in one room would in the course of two hours give off as vapour about four gallons of water, which would be visible in the clouding of windows and walls, unless the room were well ventilated" (Newsholme).

The exhaled organic matter also contributes largely to the foulness and offensive character of ill-ventilated occupied rooms. On first entering a room of this character from the fresh air the condition is at once appreciated by the sense of smell, but this appreciation is quickly dulled, and after remaining but a short time in the room the offensiveness is unnoticed; the fact that it is unnoticed no doubt explains the toleration of such a condition.

The nature of this organic matter is still uncertain; it is probably in combination with water; particles of epithelium and fatty matters are associated with it; it presents the ordinary characters of organic matter, decolourising permanganate of potash, darkening sulphuric acid, and rendering pure water offensive, when drawn through them; it blackens on platinum and yields ammonia, and is consequently nitrogenous and oxidisable; the smell is very fœtid.

Exhaled air, then, differs in various directions from ordinary air; in close and confined rooms the exhaled air is breathed and re-breathed over and over again, each time becoming more

and more charged with foulness and impurities. Foul odours, increased moisture, and raised temperature contribute in a marked and important degree to the discomfort of air from which oxygen has been abstracted, which is vitiated by excess of carbonic acid, and by added volatile organic matter and dust of various kinds; it is this combination which is most favourable to the growth and development of organisms, disease-producing or otherwise.

The consequences of habitually and for prolonged periods re-breathing air fouled by respiration and by exhalations and odours from breath, skin, and clothing are very pronounced; as an extreme and gross instance of overcrowding accompanied by fatal results the cases of the Black Hole of Calcutta may be quoted. In minor and ordinary degrees the earlier symptoms are dulness and lassitude, headache and loss of appetite, pallor and anæmia, the effects in the long run proving highly injurious to health. As might be expected, the lungs are the organs most frequently affected, and the various forms of tuberculosis, such as consumption, phthisis, or scrofula, are notoriously associated with the condition, the results being especially marked when deficient exercise and poor feeding are associated with breathing the vitiated air. In former years the prevalence of consumption amongst soldiers both at home and abroad was found by the Sanitary Commissioners for the army to be due to defective ventilation of barracks, and with improved ventilation came the diminution in pulmonary diseases. Contrasts even more pronounced characterise the former and present conditions of prisons. Air fouled by respiration is the cause of tuberculosis not only in man but in animals—cows for example, confined in close, ill-ventilated cow-sheds; the most marked improvement in the health of these animals has followed upon efficient lighting and ventilation of these places.

The increased facility of transmission of the ordinary zymotic diseases, as measles, diphtheria, etc., in polluted atmospheres, is due, first, to the more ready growth of the disease-producing organisms in such air, and, secondly, to the predisposition brought about by the lowered constitution.

As all persons are exposed to the like influences with regard to the purity or impurity of the air they breathe, the assumption of an individual predisposition to disease is rendered necessary; but as we can seldom be certain beforehand of the

presence of such predisposition, the necessary precautions to ensure the purity of the air are the more imperative.

Dr. Tilbury Fox, some years ago, related to the London Medical Society the account of a discovery he had made of the presence of the mycelium of the trichophyton in the air of a ward where a number of children suffering from tinea circinata were placed. The dust was collected on glass slides, moistened with glycerine, and then examined under the microscope.

The escape of particles of arsenic from the "rich green-flock" papers still used for house decoration has resulted in several cases of arsenical poisoning, and in one or two cases with a fatal issue.

In workshops and factories, in most cases, to the ill-effects of bad ventilation and overcrowding are added the emanations from the materials in varying stages of manufacture. The dust of grinding-shops has been found to contain large quantities of iron in very minute particles, which, by being constantly inhaled, produces the disease well known as "grinders' rot."

In "coal-miners' phthisis," the sputum is often quite black from the particles of carbon introduced into the lung during respiration. The wearing of respirators by the men engaged in trades where the production of a large amount of dust is unavoidable, has been suggested.

Gaseous Impurities.—Hydrochloric acid from alkali works, ammonia, sulphuretted hydrogen from ammonia and other chemical works, sewage gases, carburetted hydrogen, vapours from decaying animal and vegetable bodies, from slaughter-houses, bone-boilers, glue-makers, soap-boilers, etc., certain poisonous fumes from copper smelting works, brass-founders, etc.

Diseases Caused or Increased by Impure Air.—Phthisis, and other forms of tuberculosis, typhus, grinders' and miners' phthisis, a form of chronic bronchitis, granular conjunctivitis, hospital gangrene, pyæmia, erysipelas, malaise, or a feeling of illness without the presence of any specific disease.

The Purification of Air.

Mechanical methods are adopted to render air fit for human respiration, but these must only be considered as supplement-

ing, not superseding, ventilation. Filtration is frequently had recourse to, and air, after being warmed, can be moistened if it has been deprived of too much moisture.

Certain substances act chemically on air; thus, charcoal is used to purify the air issuing from drains and cesspools. Of the kinds of charcoal used, animal appears to act the best; then that made from peat. The charcoal, from whatever source, should be kept very dry, to ensure its constant activity. Unslaked lime is used to absorb carbonic acid in wells, etc. Sulphate of copper removes the odour of sulphuretted hydrogen. The ferrous sulphate is also useful in treating the stools of typhoid fever.

A solution of nitrate of lead will remove the sulphuretted hydrogen from cesspools. Solution of chloride of zinc (Sir W. Burnett's Fluid) destroys organic matter. Solution of permanganate of potash (Condy's Fluid) destroys organic matter, decomposes ammoniacal compounds, and absorbs sulphuretted hydrogen. Chromic acid, prepared by adding sulphuric acid to bichromate of potassium, is held by Smith to be a most important sanitary agent as an antiseptic.

Gases are frequently employed, more especially as disinfectants. *Nitrous Acid* acts on organic matter, but it must be used with care, as it may in some persons cause severe irritation in the lungs.

Chlorine decomposes the sulphide of ammonium and sulphuretted hydrogen, and destroys animal matter in the air.

Sulphurous Acid destroys organic matter, and, according to Guyton de Morveau, it destroys miasms. This gas is commonly used for disinfecting rooms after the occurrence of infectious sickness.

Carbolic Acid hides other odours, arrests putrefactive changes and the growth of fungi, but does not appear to have the power of ultimately destroying them. It is probably more of an antiseptic than a disinfectant. The diluted acid has been found a valuable dressing for wounds.

Iodine Vapour arrests putrefaction, but it is inferior to chlorine, as it is not so diffusible, and condenses readily.

Euchlorine.—Prepared by heating strong hydrochloric acid and potassium chlorate in a saucer. Acts like chlorine, but is less irritating to the lungs.

The Examination of Air.

The examination of air should include the investigation of the following particulars, viz.—(1) Suspended Matters, Dust and Micro-organisms. (2) Organic Matter. (3) Carbonic Acid. (4) Watery Vapour. (5) Ammonia.

1. Suspended Matters.—These are ascertained by slowly drawing the air through an aspirator over glass slides moistened with glycerine, which collects the solid matter suspended in the air.

Pouchet's Aerescope is usually employed. Its construction is very simple, consisting of an air-tight chamber with two openings, into one of which is fitted a small funnel, the stem of which is drawn into a fine point; into the other, a glass tube connected to the aspirator by india-rubber connections. A glass slide moistened with glycerine is placed so that the air drawn through the funnel may impinge upon it. The slide may then be placed under a microscope and examined.

Dr. Parkes objects to the use of glycerine on account of the difficulty of procuring it perfectly free from foreign particles. He recommends the following plan:—A small bent glass tube is taken, carefully washed and dried, and then heated to redness; when cool it is inserted in a freezing mixture, and one end attached to an aspirator by a piece of india-rubber tubing. The air is then slowly drawn through, and the moisture of the air containing the suspended matter is condensed; a drop may be then placed on a slide and examined as in the former case.

An aspirator may be made by procuring a box of a known capacity (*i.e.* one cubic foot), with openings in it, like that used by Fouchet, to contain the slide, but, in this case, filled with water. As the water is allowed to run out at one aperture, air rushes in at the other, and if this be attached to the box containing the slide, or to Parkes' bent tube, air will be drawn through them. In every case the air should be drawn very slowly through the aspirator.

Micro-organisms are roughly estimated by the number and variety of colonies obtained after exposure, for a certain time, of nutrient material in ordinary Petri dishes to the air to be examined. By Hesse's apparatus a measured quantity of air is drawn through a pin-hole into a cylinder smeared with sterile

nutrient material, upon which the organisms are deposited. These methods will, of course, only reveal the presence of such organisms as will grow upon the media used, and to whose growth the surrounding conditions are favourable. Bacteria are not found in the pure air of mountainous regions nor at sea; at Montsouris the maximum number was found in July, the minimum in February (see p. 524).

2. Organic Matter.—This is determined by a solution of permanganate of potash, through which a definite quantity of air is drawn, and the amount of undecomposed potassium permanganate determined by oxalic acid. This process does not admit of satisfactory results, as it only indicates the amount of oxidisable matter present in different samples of atmospheric air, without giving any indication whence this oxidisable matter is derived, whether from animal or vegetable substances. Nitrous, sulphurous, and other acids present in the air produce the same reaction, thus rendering the test useless as to the actual presence of *organic* matter.

Mr. Moss proposes the following mode of procedure:—A known quantity of air is drawn through distilled water. The water is then examined on Wanklyn's plan for free and albuminoid ammonia.

3. Carbonic Acid.—A simple method of ascertaining this is by the degree of milky coloration which a known volume of air gives rise to with a standard solution of lime or baryta water.

Dr. Angus Smith's Method.—A clean wide-mouthed stoppered bottle, capable of holding seven ounces, is taken, and air drawn into it by means of a glass tube, care being taken not to breathe into the bottle. Put in half an ounce of clean baryta water (·08 of a gramme of baryta), close the bottle, and shake. If the air should contain less than ·03 per cent of CO_2 there will be no precipitate. Lime water may be used instead of baryta water, but in that case the bottle must be larger, owing to the greater solubility of carbonate of lime, and the consequent difficulty in recognising the beginning of opacity. In using lime water a graduated pipette is necessary to draw out the required half-ounce of lime water.

By the following Table the amount of carbonic acid present in the air is indicated by the size of the bottle required to produce a precipitate with half an ounce of lime water:—

Carbonic Acid in the Air.	Size of Bottle to be used with half an ounce of Lime Water, no precipitate produced.
·03 per cent.	20·63 oz. avoirdupois.
·04 ,,	15·60 ,,
·05 ,,	12·58 ,,
·06 ,,	10·57 ,,
·07 ,,	9·13 ,,
·08 ,,	8·05 ,,
·09 ,,	7·21 ,,
·10 ,,	6·54 ,,
·15 ,,	4·53 ,,
·20 ,,	3·52 ,,
·25 ,,	2·92 ,,
·30 ,,	2·51 ,,
·50 ,,	1·71 ,,
1·00 ,,	1·10 ,,

Dr. Smith proposes the following rule as a practical application of this method :—Let us keep our rooms so that the air gives no precipitate when a $10\frac{1}{2}$ oz. bottleful is shaken with half an ounce of clear lime water.

Pettenkofer's Method.—Take a glass vessel capable of holding from half a gallon to a gallon and a half, and determine its exact capacity by filling it with water and measuring the contents by means of a pint measure ; 1 ounce = 1·733 cubic inches. The vessel should be carefully dried, and then filled with air, by means of a pair of bellows, taking care that the nozzle of the bellows reaches the bottom of the jar. When full, pour in rapidly 60 c.c. of clear lime or baryta water (pure baryta, 7 grammes ; water, 1 litre) ; cover the mouth of the jar with an india-rubber cap, shake well, so that the liquid may flow over the sides, and then set it aside for not less than six or eight hours or more than twenty-four. By the absorption of the carbonic acid by the lime or baryta water, the causticity of these fluids is lessened, and on this fact the test depends, for if the causticity of the lime solution be known both before and after the experiment, the amount of CO_2 can be calculated.

A solution of crystallised oxalic acid is used to determine the causticity of the lime, the strength of which should be 2·25 grammes of pure crystallised oxalic acid to the litre of

distilled water. Now take 30 c.c. of the lime or baryta water from the jar, and carefully neutralise it by running in from a graduated burette the standard oxalic acid solution. The exact point of neutralisation is determined by dropping from time to time a drop of the liquid on turmeric paper. The stain produced before the addition of the oxalic acid is of a dark brown colour, but as the oxalic acid is run in, the centre of the drop becomes gradually free from colour, and only the margin appears of a delicate brown shade. Care must now be taken only to drop in very small quantities at a time till the coloured margin also disappears, when the point of neutralisation is reached.

Having determined the causticity of the lime solution in the jar, next determine the causticity of the original lime water, and then multiply the difference between the two quantities by 790, and divide the product by the number of cubic centimetres contained in the jar *minus* 60. The result will be the ratio of carbonic acid per 1000 volumes. Care should be taken that the baryta water be absolutely free from potash or soda. A correction must be made for temperature. Wilson gives the following simple rule:—For every 5° above 62° F. add 1 per cent to the amount of CO_2, calculated as above, and deduct the same for every 5° below 62° F.

In ordinary cases, the barometric pressure may be omitted, but if it be required to examine the air at any considerable height, adopt the following:—

$$\frac{\text{Standard height of}}{\text{barometer (30 inches)}} : \frac{\text{observed}}{\text{height}} :: \frac{\text{capacity}}{\text{of jar}} : X.$$

The result expressed by X is substituted for the actual capacity of the jar in the previously mentioned calculation for CO_2.

4. Watery Vapour.—Determined by various forms of hygrometers. A healthy amount of moisture and heat is shown when the dry bulb thermometer stands at 60° F., and the moist bulb about 55° F. The difference should not be less than 4° or more than 8°.

5. Ammonia.—To perform this test, the air must be drawn through distilled water, previously tested as to its freedom from ammonia. (See account of the Nessler Test, p. 513.)

VENTILATION.

The importance of a knowledge of the principles of ventilation cannot be over-estimated, yet there is probably no branch of knowledge over which so much erudition is expended, and so little really accomplished. A knowledge of the principles of ventilation implies an intimate acquaintance with the general properties of gases and vapours, the nature and composition of atmospheric air, and the changes to which it is subject from the effects of the respiration of animals, the modifying influences of vegetation and climate, and the results of the combustion of certain bodies to produce either artificial heat or light.

General Properties of Gases and Vapours.

A *gas* is an aeriform body characterised by a marked tendency to occupy a larger space; and hence it has neither an independent form nor an independent volume. Oxygen and hydrogen have of late been liquefied, thus effacing the old distinction between permanent and non-permanent gases. Professor Dewar has succeeded in liquefying air.

A *vapour* is also an aeriform body, differing from a gas in its comparatively easy reduction to a liquid condition—the vapour of water

Law of Diffusion of Gases and Vapours.

Gases differ from liquids in this, that, if gases of varying density be poured into a tall jar, in a short time the mixture in every part of the jar will be the same; and this mixture of gases will take place even through animal membranes or considerable thicknesses of any porous material. If two jars be taken, one containing hydrogen and the other oxygen, separated by a layer of plaster of Paris, and so filled that the lighter hydrogen be placed above the heavier oxygen, an interchange of gases will take place, which may be proved by an explosive compound being formed, and which, on the application of a match, will go off with a loud report. The passage of an electric current through the mixture will also cause an explosion, with, as in the former case, the production

of water—thus showing that the previous mixture of the gases was a purely mechanical one.

The following laws should be remembered :—

BOYLE'S OR MARIOTTE'S LAW.—The law is as follows :—*The temperature remaining the same, the volume of a given quantity of gas is inversely as the pressure which it bears ; or, for the same temperature, the density of a gas is proportional to its pressure.*

This law has of late been shown to be only approximately true, for Regnault found that air does not exactly follow Boyle's law, but experiences a greater compressibility, which increases with the pressure ; so that the difference between the calculated and the observed diminution of volume is greater in proportion as the pressure increases. Non-saturated vapours obey Boyle's law, but saturated vapours are incompressible, a portion being liquefied with any increase of pressure, and the tension which is left in the state of vapour remaining constant.

The correction of gases for pressure and temperature may be made by the following formula :—

X = final volume.
a = volume of gas.
H = original pressure.
h = final pressure.
T = original temperature.
t = final temperature.

$$X = \frac{a \times H(273+t)}{h(273+T)}.$$

Example.—What volume will 50 cubic feet of air, measured when the temperature is 15° C. and barometric height 30 inches, occupy when the temperature becomes 25° C. and the barometric height 28 inches.

$$x = \frac{50 \times 30(273+25)}{28(273+15)} = 55 \cdot 43.$$

Nitrogen closely resembles air, but CO_2 shows considerable deviation from the law, even under small pressures.

CHARLES' LAW.—*The volume of a gas is directly proportional to its absolute temperature, reckoned from its absolute zero, that is, 273° C. below 0° C.*

Thus 273 volumes at 0° C. become
274 ,, at 1°
275 ,, at 2°.

Also 273	volumes	at 0° C.	become
272	,,	at 1°	
271	,,	at 2°	
270	,,	at 3°.	

The absolute zero is that degree of cold which ceases to affect a gas as cold usually does.

GRAHAM'S LAW.—*The ratio of diffusion of gases is inversely proportional to the square roots of their relative weights or densities.*

To find the specific gravity of a gas, divide the weight of the gas by the weight of an equal quantity of hydrogen, or air. whichever be taken as a standard. For example—

A glass globe	full of air	weighs	1272·67
,,	full of CO_2	,,	1279·27
,,	empty	,,	1260

$$1272{\cdot}67 - 1260 = \text{weight of air} \quad 12{\cdot}67$$
$$1279{\cdot}27 - 1260 \quad ,, \quad CO_2 \quad 19{\cdot}27$$
$$19{\cdot}27 \div 12{\cdot}67 = 1{\cdot}52 \text{ sp. gr. } CO_2.$$

From the experiments of Feddersen of Leipzig, it appears that when a porous substance acts as a diaphragm between the same gases, the pressure on each being the same, the passage of the gas takes place from the cold to the warm side.

In considering the question of ventilation, there are three important points to be borne in mind :—

1. The capacity of the room—that is, the amount of cubic space which it contains.

2. The number of individuals normally present in it. *An allowance must also be made for the number of gas-jets, lamps, candles, fireplaces, etc.*

3. The efficiency of the means for introducing pure air, and allowing the vitiated to escape.

1. THE CAPACITY OF THE ROOM, ETC.

In calculating the cubic space of any given apartment, the height, length, and breadth must be multiplied together, allowance being made for any recesses, cupboards, and also for the bodies of the occupants, an average of three cubic feet being allowed for each individual. The weight of a man in stones

divided by 4, gives roughly the cubic space occupied by him. The space occupied by articles of furniture must also be considered. If the room be irregular in shape, it must be divided into several imaginary triangles or squares, the sum of which will give the size of the room. After these various corrections, the remaining number of cubic feet divided by the number of individuals will give the cubic space per head. It must be borne in mind that the purity of the air in a room does not depend upon its size, but on the rate at which impurities are produced, and the rate at which fresh air can be introduced without producing draughts.

Measure in feet and decimals of a foot. Convert square inches into square feet by multiplying by ·007.

Area of a Triangle	= Base × $\frac{1}{2}$ height, or B × H ÷ 2, or H × $\frac{1}{2}$B.
Area of a Circle	= D_2 × ·7854, or C_2 × ·07958, or $\frac{1}{2}$C × $\frac{1}{2}$D.
Area of Rectangle	= Multiply two sides.
Area of Parallelogram	= Multiply a side by its width on the square.
Area of Trapezium	= Multiply the diagonal by the sum of the two perpendiculars falling upon it from the opposite angles, and divide the product by 2, or divide into any number of convenient triangles, and take the sum.
Area of Trapezoid	= Take one-half the sum of the parallel sides, and multiply by the distance between them.

Cubic Contents.

Cubic contents of a Cone	= area of base	× $\frac{1}{3}$ height.
,, ,, *a Cylinder*	= ,,	× height.
,, ,, *a Dome*	= $\frac{2}{3}$ area of base	× height.
,, ,, *a Sphere*	= D_3 × ·5236.	

The cubical capacity of a marquee, used as a provisional hospital, may be found by dividing it into—

(1) *Body*—A solid rectangle, with a half cylinder at each end.
(2) *Roof*—Solid triangle and two half cones.

The minimum amount of space allowed by the Poor Law (Local Government) Board in dormitories is 300 cubic feet, which, to allow 3000 cubic feet of air for each person, necessitates that the air be changed at least ten times during the hour.

2. Number of Individuals Normally Present.

When the number of persons occupying a room sought to be ventilated is always the same, there can be little difficulty in supplying the proper amount of pure air per head ; but when the numbers are constantly subject to change, considerable difficulty may be experienced in making the necessary arrangements to supply the varying demand. This was one of the difficulties with which Dr. Reid had to contend in his proposal for ventilating the Houses of Parliament. Putting aside this difficulty, it may be stated in general terms that sufficient air should be supplied to each individual, so that the amount of carbonic acid present in the air of the room should not exceed ·6 per 1000 volumes, the amount of carbonic acid present being taken as the index of the organic impurity, allowance being made for ·4.CO_2 naturally existing in the atmosphere.

Air required by Individuals.—Three to four cubic feet of air are required by each individual per minute. Windows, as usually constructed, will admit about eight cubic feet per minute.

To find the number of persons who may occupy a room.—Multiply the height, length, and breadth of the room together, and divide by the number of cubic feet of air proposed to be allowed for each person. Thus—

$$10 \times 20 \times 10 = 2000 \div 400 = 5.$$

To calculate the quantity of fresh air required per hour for each individual :—

$$y = \frac{k}{p - q}.$$

y = volume of air required.
k = volume of CO_2 produced by persons, lights, etc.
q = proportion of CO_2 to be allowed to reach volume of air.
p = proportion of CO_2 existing in normal air.
p = ·0007 per volume of air.
q = ·00037 per volume in normal air, or ·0004 per cubic foot.
The value of p and q varies with different writers.

3. Efficiency of Means for introducing Pure Air, and allowing the Vitiated to escape.

(*a*) The entering air must be pure, of a proper temperature, and supplied at the rate of 3000 cubic feet per head per hour.

(*b*) There should be no draught.

The rate at which air moves through a room depends on the differences of temperature between the internal and external air, and the efficiency of the mechanical means adopted for drawing the air through the room. A velocity of from 1 to 2 feet per second, at a temperature of 60° F., will not cause a draught, and will yet answer the purpose of ventilation. The velocity should not be more than 19 inches, or a little more, per second ; it is better to enlarge the channels. A draught is produced if the air be changed oftener than six times an hour, or if the velocity be from 3 to 3½ feet per second. A draught is the one-sided cooling of the body, or some part of it, by cold air in motion, or by increased one-sided heat radiation. As a result, there is a local perturbation of our heat economy, the cold air acting on the nerves which regulate the calibre of our blood-vessels.

(*c*) The air must be diffused through the room ; in no part ought it to remain stagnant.

(*d*) There must be means provided for the escape of the foul air, and entrance of the pure.

In England 24 square inches of outlet and inlet per head is sufficient.

It may be well to note here the results of Pettenkofer on the permeability of brick walls, and the passage of air through them :—

The room had brick walls, and contained 2650 cubic feet. With a difference of temperature of 34° F. (66° inside and 32° outside), the air in the room was changed once, equal to 2650 cubic feet per hour. With the same difference, but with a good fire and a free vent up the chimney, the change of air rose 3320 cubic feet, or about 25 per cent more. With all the openings and crevices pasted up, there was still a change of 1060 cubic feet, or a fall of 28 per cent. With a difference of temperature of 7° F. (71° inside and 64° outside), the change amounted to only 780 cubic feet per hour. With a window open of 8 square feet, the change was 1060 cubic feet per hour. Thus, a difference of temperature of 34°, with carefully shut windows and crevices, is of greater influence than large communications with the outer air at a small difference of temperature.

Marker and Schultze have found that the spontaneous ventilation through one square yard of the following substances, with a difference of 4° F., amounted per hour :—

Sandstone	to 4·7 cubic feet.
Quarried limestone	to 6·5 ,,
Brick	to 7·9 ,,
Tufaceous limestone	to 10·1 ,,
Mud	to 14·4 ,,

Direction and Movement of Air.

The direction or movement of the air in a room may be determined by burning brown paper and noticing the direction taken by the smoke, or the direction taken by small particles of light substances, or the effect produced on the flame of a candle. First determine the direction, and then proceed to measure the discharge, which is, of course, equal to the amount entering. The velocity may then be determined by an *anemometer*, or by the *manometer*, or by *calculation*.

The anemometer is a delicate instrument which records the lineal velocity of wind, and consists of light metal vanes attached to a common axis, the revolutions of which are recorded upon dials. The instrument is placed in the opening through which the air passes, and the velocity for say one minute is observed, and the rate per second or per hour calculated from this.

To find the amount of air discharged at a given velocity by an opening or vane.—The velocity in feet per second, multiplied by the area of the discharge pipe in square feet, will give the number of cubic feet of air discharged per second. Thus, $70 \times 3 = 210$ cubic feet per second $\times 60 =$ per minute.

To find the weight of air passed through an opening at a given velocity.—A cubic foot of air weighs at 60° F. 536·28 grains—that is, about 13·05 cubic feet to the pound; hence, as in the last case, $\frac{210 \times 60}{13 \cdot 05} = 965 \cdot 40$ lbs. weight of air is set in motion per minute with a velocity of 70 feet per second. If it be now asked to calculate the power required to discharge this weight of air at the given velocity, we proceed as follows:—

$$\frac{76 \cdot 5 \times 965 \cdot 40}{33{,}000} = 2 \cdot 220 \text{ horse-power.}$$

The divisor, 33,000, is the number of pounds weight one horse will raise one foot high per minute; 76·5 is the height from which a body must fall to acquire a velocity of 70 feet per second.

To calculate the expansion of air by heat:—

$$M' = (1 + at)M.$$

M = volume at 32°, barometer 30 inches.
M' = volume at the temperature of t degrees above 32° F.
a = coefficient ·002036 for each degree F., or ·003665 for 1° C.

To calculate contraction of air from decrease of temperature:—

$$M' = (1 - at)M.$$

To find the weight of a cubic foot of air at different temperatures and pressures:—

$$\frac{1 \cdot 3253 \times \text{height of barometer}}{459 + \text{temperature F.}} = \text{lbs.}$$

One pound of coal requires 300 cubic feet of air at 62° F. for its complete combustion, and one pound of dry wood 160 cubic feet.

Given the amount of coal consumed, and the size of the room, the exhausting effect of the fire can be calculated, especially if we consider that a common fireplace extracts 3 to 6 cubic feet per second, and a strong fire 6 to 8 cubic feet.

The velocity of air through public buildings, etc., may be measured by anemometers placed in the outlets.

Ventilation may be either—

(1) Natural, or (2) Artificial.

1. **Natural Ventilation.**—Under this division may be classed all those naturally operating causes by which foul air is removed, and pure air introduced, without the aid of any mechanical means, the efficient causes here at work being *the expansion of air by heat, the diffusion of gases, and the force of the wind*. The air of the room, heated by respiration and by contact with the human body, at the same same time becoming vitiated by the products of respiration, rises to the upper part of the room, and then escapes by any outlet which it may find. Cold air finds its way in from any orifice situated near the ground, such, for instance, as the chinks of doors and windows, and thus by natural means ventilation is established. Fires in open grates act in a similar way; a strong upward current is caused by the warm air rushing up the chimney, and cold air from below supplying its place. Modern fireplaces only ventilate as high as the opening into the chimney, the air above the mantelpiece remaining for the most part stagnant. Chimneys without fires act as useful ventilators; for the wind blowing over their tops creates a partial vacuum, which is being constantly filled with air from the house. This is due to the aspirating power of the wind. Chimneys may become inlets, due to the following causes:—

1. If there be two fireplaces in one room, the one with a fire may cause a down-draught in the other.

2. The fires lighted in the grates in the top rooms of a

house may draw air down the chimneys opening into the lower rooms.

3. The flues may be too high for the size of the fire, the heat from which is not sufficient to heat the whole column of air in it. In such a case there is little draught to carry off the smoke, which accordingly enters the room.

4. If a chimney is commanded by higher buildings, the wind blowing over them pours like water over a dam, and passes down the chimney.

5. If, when a fire is lighted in a grate, there is not sufficient air admitted to the room to feed the fire, a down-draught is created. The above are also some of the causes of smoky chimneys.

It is found that, practically, the natural modes of ventilation are not sufficient for the requirements of thorough ventilation; for in some climates the air may be as hot outside as inside the house, and when this is the case there may be also a dead calm; besides, a greater velocity in the air, and a more rapid interchange, are required in rooms where men or animals are congregated together, than can be obtained by the unassisted powers of Nature. "A top window-sash, lowered a little, instead of serving, as many people believe it does, like such an opening into the chimney flue, becomes generally, in obedience to the chimney draught, merely an inlet of cold air, which first falls as a cascade to the floor, and then glides towards the chimney, and gradually passes away by this, leaving the hotter, impure air of the room nearly untouched." A window may, however, be readily used as a ventilator by opening the window and placing a piece of board about six inches deep, and the full width of the window, under the bottom sash, which is then closed down upon it. By this means an air space is left between the two sashes, and the entering air is directed towards the ceiling, and is thus more equally diffused. This is Dr. Hinckes Bird's method. If there is not sufficient difference of temperature between the outside and the inside, a partial opening of the windows during a winter night is just as necessary as during a summer night. The watery vapour exhaled by the sleepers condenses against the walls, and obstructs the pores. A part is evaporated during the day, but it will be only a part; and hence the not infrequent breaking out of damp spots in such dormitories during the winter.

2. **Artificial Ventilation.** — Artificial ventilation, on the other hand, includes all those appliances which may be strictly termed mechanical. The punkah used in India is one of the simplest of these appliances, and consists of a huge fan suspended over a table or bed, and manipulated by a cord pulled by an attendant outside. All the so-called mechanical appliances, however, owe their efficiency to the utilisation of already existing natural agencies. Of these appliances it will be necessary to mention a few of the more important. In some cases it has been proposed to ventilate a room by means of a hollow beam carried from one outer wall to the other. A partition in the middle divides the beam into two equal parts. The wind blowing into one end enters the room by holes made in it, whilst the vitiated air escapes by similar holes in the other end. Rooms may be also ventilated by shafts, etc., opening in the room near to the ceiling; for those in rooms next the roof, a sectional area of one inch to every 50 cubic feet of room space is required; for floors one storey from the ground, one inch to 55 cubic feet; and for the ground floors, one inch in 60 cubic feet. For inlets, one square inch for every 60 cubic feet of room space (Galton). All channels for the supply of air should be short, straight, and so placed as to be readily inspected and cleaned. In hot climates it is often necessary to cool the air before allowing it to enter the rooms. This may be done by taking advantage of the law of the cooling of gases by expansion. A steam-engine is used to compress the air, and the air so compressed and heated is cooled by passing it over iron tubes through which cold water circulates. In its compressed and cooled condition it is allowed to escape into the rooms, producing by its expansion a further reduction in temperature. Snow-flakes may even be formed by the air as it enters the room.

Sylvester's Method.—This was in use more than fifty years ago, but its application dates from very ancient times. By this plan, the agency of the wind is utilised by the aid of a cowl, which is constantly directed to that quarter from which the wind blows. The cowl is connected to pipes distributed throughout the house, and through which the fresh air enters the various rooms; another system of pipes is also connected to another cowl turned from the wind, by which the hot vitiated air is removed. Sylvester's method, therefore, com-

bines *perflation*, or blowing in, and *aspiration*, or sucking out. This plan has been largely adopted on sailing-vessels, where the ordinary "wind-sail," for carrying the fresh air in, is the

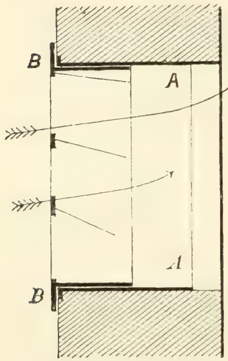


FIG. 62.—Chimney valve. BB, inner wall surface; AA, valve-box; C, chimney. The arrows indicate direction of currents of air.

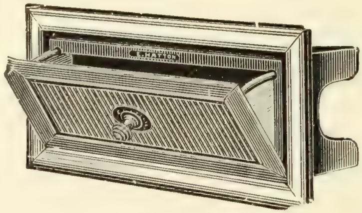


FIG. 63.—Hatton s screen valve.

only part of the system used, the impure air being allowed to find the best way out for itself. The great drawbacks to this system are—that during periods of calm, the cowls are next

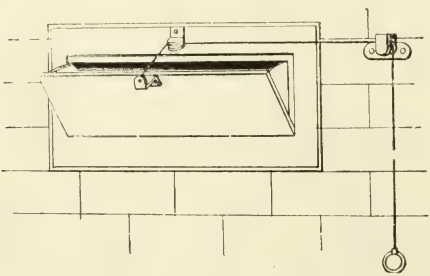


FIG. 64.—Sheringham's valve.

to useless, whilst, when the wind is high, neither the amount of air admitted can be regulated to prevent draughts nor a suitable temperature maintained.

Dr. Neill Arnott's Method.—Ventilation by means of a hole cut in the chimney as close to the ceiling as possible was suggested in 1849 by Dr. Arnott. Several forms of valves for placing in holes near the ceiling have been invented; but a description of their individual merits is not necessary here. The best of these, however, is the Sheringham valve. One objection to Arnott's hole in the chimney is, that sometimes a down-draught forces the soot into the room. He also proposed a modification of Sylvester's plan, with which he ventilated the Field Lane Ragged School.

Potts's Method.—This consists in placing behind the cornice of a room a tube divided into a lower and an upper compartment. Each compartment is pierced with small holes. The lower is connected by pipes with the external air, the upper with the chimney or other hot-air shaft. The pure air is supposed to enter by the lower and sink gradually to the floor, and the products of respiration escape by the other, which is connected with a chimney or ventilating shaft. Mr. Varley's plan is a modification of Potts's, in that the pure air is brought in on three sides of the room, and the foul air extracted on the fourth side, connected with the chimney.

M'Kennell's Method.—This consists of two tubes, one encircling the other, the inner tube being always longer than the outer, and protected by a cowl. The tubes are so constructed that the transverse area between them is equal to the sectional area of the smaller. The inner is the outlet tube, and has a flange attached to its lower end, which helps to turn the incoming air towards the ceiling, and thus enables it to diffuse equally about the room. Both tubes become *inlets*, if there is a fire in the room; if the door and windows are open, both become *outlets*. The tubes should be placed in the centre of the room, and are best adapted to the ventilation of upper rooms or one-storeyed buildings, of square or round rooms, chapels, or churches, the diameters of the tubes being adjusted to meet the requirements of the case.

Stallard's Method.—This is proposed for workshops and factories, and consists in having two ceilings, the lower one of perforated zinc or oiled paper. The space between the two ceilings is open on all sides to the atmosphere.

Tobin's Method—Ventilation by Vertical Pipes.—The origination of this plan is also claimed by Messrs. Shillito and

Shoreland. The air is brought into the room by tubes placed vertically in the walls, with openings in the room about six feet from the floor. The advantages claimed are that, by admitting air into a room above the heads of the occupants,

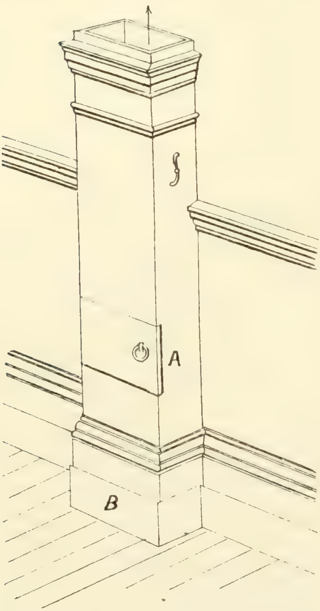


FIG. 65.—Tobin's tube. By means of the opening at A the tube may be periodically cleaned, and by means of the handle on the right side of the tube, which acts on a valve in the throat of the tube, the amount of incoming air may be regulated.

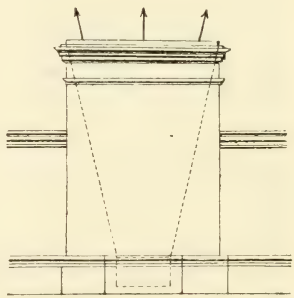


FIG. 66.—Another form of Tobin's tube. This is shorter than Fig. 66, and is based on the principle that a current of air passing in a confined channel from a narrow point to a broader loses velocity. In this form of tube, although air may be entering rapidly at the contracted throat, it has lost all its harmful effects before it reaches the broader part at the top of the tube.

all draught is avoided, and a perfect renovation of the air produced, free from the necessity of constant watching.

The great failing of this system appears to consist in the smallness of the tubes used, and the difficulty experienced in ensuring the proper action of the inlet tubes, their intended action being liable to be reversed. There is also a good deal of friction in the tubes, and insects and dust may also accumulate

in them. The size of the inlet should be about 24 square inches per head, and the same for outlet.

Van Hicke's System.—This is used in some of the hospitals in France and Austria. A large fan forces the air into the basement, where it is warmed and distributed to the wards.

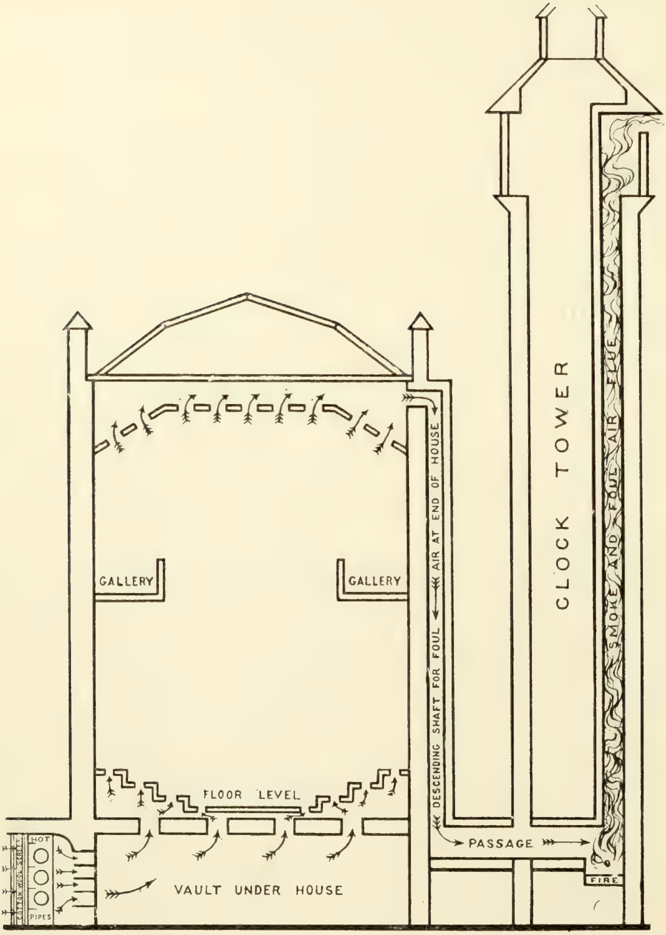
Ventilation by Extraction—known also as the Vacuum Method.—It was by this method Dr. Reid ventilated the Houses of Parliament, and it consists in connecting the apartment to be ventilated by means of tubes with a ventilating shaft, at the bottom of which a fire is kept burning. An upward current is produced, fed by the air from the tubes. Pure air, carefully warmed, is admitted into the room as fast as the vitiated air is removed. The air in the Houses of Parliament was admitted through minute perforations in the floor. It is on this principle that *mines* are ventilated by what is known as an *upcast* and a *downcast* shaft. The downcast shaft, through which the air enters the mine, is so connected with the galleries that the air shall first circulate through the mine, and then pass out by the upcast shaft, at the bottom of which a fire is kept burning.

Steamships are ventilated on the same principle as mines, by simply connecting the several parts of the ship with a tube above the furnace fires.

To produce thorough ventilation by a shaft, the shaft must be made as high as possible, for any diminution in its height must be compensated for by increased heat in the shaft, with a consequent increase in the amount of fuel required. The upflowing air should meet with as little friction as possible, and the difference between the internal and external temperature be constantly maintained. General Morin found that, in winter, the ventilation by the shafts in the *Conservatoire des Arts et Métiers* was maintained by the expenditure of 1 lb. of fuel for 8700 cubic feet; in summer, only 3000 cubic feet were removed by the same amount of fuel. There are many modifications of this system, but the principle involved is the same.

Several objections have been raised, of which the following alone demand attention :—

1. The inequality of the draught, due to the difficulty of always maintaining the fire at the proper height.
2. The inequality of the movement of the air in the several rooms, those nearest the shafts being more rapidly exhausted than those at greater distances.



1,500,000 CUBIC FEET OF AIR EXTRACTED PER HOUR.

FIG. 67.—System of warming and ventilation adopted at the House of Commons.

3. Regurgitation of smoke from the shaft into the rooms.
4. Difficulty in controlling the supply of fresh air at a proper temperature.

Ventilation by Propulsion—known as the Plenum Method.—This was proposed by Dr. Desaguliers in 1734, and consisted in forcing in the air by means of a fan-wheel enclosed in a box. By reversing the action of the wheel, the air could be drawn out of the apartment. St. George's Hall, Liverpool, is ventilated by propulsion; the air being first washed, and heated in winter and cooled in summer, is forced through tubes into the building.

As an example of the strictly mechanical means by which ventilation may be effected, the case of the Senate House in America may be mentioned. In this, a large fan, worked by a steam-engine, draws in the fresh air, which, after being warmed by passing over hot pipes, is distributed throughout the house—the amount of air supplied being regulated by calculating the quantity required for each individual present.

Both methods, extraction and propulsion, have advantages and disadvantages. With extraction the amount of current varies with the degree of heat; in the case of large buildings, the rooms nearest the shaft will have a strong current, whilst those at a distance from it will have little or none; the possible reversal of the current with this method must not be lost sight of. With propulsion there is more certainty in amount, and greater ease with which that amount can be supplied; moreover, the purity of the intake can be assured. There is, however, usually greater cost, and possibility of breakdown to be remembered, and careful attention to detail is always necessary with this system.

Schedule VII. of the Code of Regulations of the Education Department contains the following rules to be observed in planning Public Elementary Schools:—

"Apart from open windows and doors, there should be provision for copious inlet of fresh air; also for outlet of foul air at the highest point of the room; the best way of providing the latter is to build to each room a separate air chimney carried up in the same stack with smoke flues. An outlet should have motive power by heat or exhaust; otherwise it will frequently act as a cold inlet. The principal point in all ventilation is to prevent stagnant air. Particular expedients are only subsidiary to this main direction. Inlets are best

placed in corners of rooms farthest from doors and fireplaces, and should be arranged to discharge upwards into the rooms. Inlets should provide a minimum of $2\frac{1}{2}$ square inches per child, and outlets a minimum of 2 inches. All inlets and outlets should be in communication with the external air. Rooms should, in addition, be flushed with fresh air about every two hours. A sunny aspect is especially valuable for children, and important in its effects on ventilation and health."

Having now given a short outline of the various plans which have been suggested for the ventilation of houses and other buildings, it is well to bear in mind the remarks of Mr. Tomlinson, that "in the rooms of private houses the ventilation must also be spontaneous; for if the slightest trouble be entailed on the inmates, even to the opening of a window, it will be neglected. The means for ventilation must be cheap, easily procurable, always in place, self-acting, not liable to get out of order, requiring no adjustment, no care whatever on the part of the inmates."

Law on the Subject of Ventilation.—No provision is made by law for the enforcement of proper ventilation in dwelling-houses, but in the case of factories the following has been enacted :—

Every factory to which this Act applies shall be kept in a cleanly state, and ventilated in such a manner as to render harmless, so far as is practicable, any gases, dust, or other impurities, generated in the process of manufacture, that may be injurious to health.

By another Factory Act greater provision is made for every factory where grinding, glazing, or polishing on a wheel, or any other process is carried on by which dust is generated and inhaled by the workmen to an injurious extent, etc. Occupier must provide fan, or other mechanical means, to remove nuisance.

WARMING.

Warming is closely associated with ventilation. There are three ways in which heat is distributed, viz.—(*a*) By *radiation*, in which the heat given off by the warming object, *e.g.* burning coal in an open grate, is propagated in straight lines, with equal intensity in all directions, but with an effect which diminishes as the square of the distance increases ; this method is no doubt wasteful, but at the same time it is the natural one and the most pleasant, being typified in the warmth of sunshine ; the open grate and the sun warm in the same extravagant

but agreeable fashion. (*b*) *Conduction* is another well-known form of distribution of heat; it consists of the more or less slow passage of heat through certain solids. A familiar illustration is furnished when a silver spoon is used in hot liquid; it soon becomes warm throughout by the conveyance of heat from particle to particle of the spoon until the whole is affected; similarly if one end of a metal bar be thrust into the fire and allowed to become red hot, the other end becomes hot by the process of conduction. Conduction incidentally plays an important part in warming rooms, as for example when the ironwork or other solid conducting structures around grates and stoves become hot by this means. *Liquids* and *gases* are bad conductors, but heat is distributed in them in the third manner, namely, by *convection*. (*c*) By *convection* is understood the fact that the particles of gas or liquid expand as a consequence of being heated, become lighter, and rise, their place being taken by colder and consequently heavier ones; if a vessel containing water be heated, and a few fragments of cochineal dropped into it to indicate the currents, it will be seen by appropriately placed thermometers that the warm particles of water ascend in the centre, while the cold ones descend by the sides. The atmosphere, like all other gases, readily expands by heat; consequently convection is very marked, and convection currents are important adjuncts in warming.

Ordinary dwelling rooms in this country are almost invariably warmed by open fires, a method to be commended as not only cheerful but healthy, on account of the ventilation ensured by it. In the case of large rooms such as schoolrooms this means cannot be regarded as efficient, since about 75 per cent of the available heat from the combustion of fuel is with the ordinary open fireplace lost up the chimney. Various measures, however, are taken to construct grates so that combustion shall be slow and fuel economised. The points aimed at are (1) to use fire-brick instead of iron; (2) the fireplace should be narrow, the back leaning slightly forward over the fire; (3) beneath the fire the space should be closed in front by a close-fitting shield. Suitably placed central stoves with open grates, such as Boyd's, can be sometimes used, the flues from which pass under the floors. In halls and vestibules stoves are sometimes employed to warm the fresh air as it passes in from without; George's Calorigen stove is upon this principle, which is sufficiently

explained by the diagram. Many adaptations of this principle are in use. Stoves which do not provide means for the inlet of fresh air as well as for the removal of the products of combustion should be excluded, and it is unnecessary to say that any stove which is liable to become overheated should be condemned.

Hot-water pipes constitute one of the simplest and best means of warming; the pipes are usually from 2 to 4 inches in diameter, and are connected with a boiler usually placed in the basement; they are arranged in a double row to allow the water to circulate.

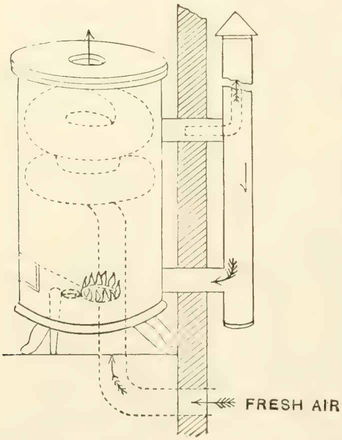


FIG. 68.—George's "Calorigen" gas stove.

The temperature should be kept at about 56° to 60° Fahr.; if the corridors, lobbies, etc., are also warmed by pipes this degree is more easily maintained. Warming by means of hot-water pipes can with great advantage be supplemented by open grates, which can be used occasionally, and their flues are always available for ventilating purposes.

Fig. 69 indicates the method of warming and ventilation of a large Board School. The fresh-air inlet is shown on the left (A), the air is warmed at B, filtered at C, and following the direction of the arrows, passes through the class-rooms, and is extracted at the shaft (K), connected with the boiler-house (L).

Phenomena of Heat.—A glass house is a "trap to catch a sunbeam," the glass allowing the radiant heat from the sun to pass through, but obstructing the obscure rays radiated from the walls, etc. Hence, a glass screen before a fire will obstruct the obscure rays of heat radiated from the fire; but will allow the radiant heat to pass; and this is especially the case if the heating body be a stove. The action of the "cosey" may be thus explained. If the surface of the teapot be black or dark, heat is rapidly radiated, its loss being prevented by the cosey, which, being usually made of bad conducting material, radiates

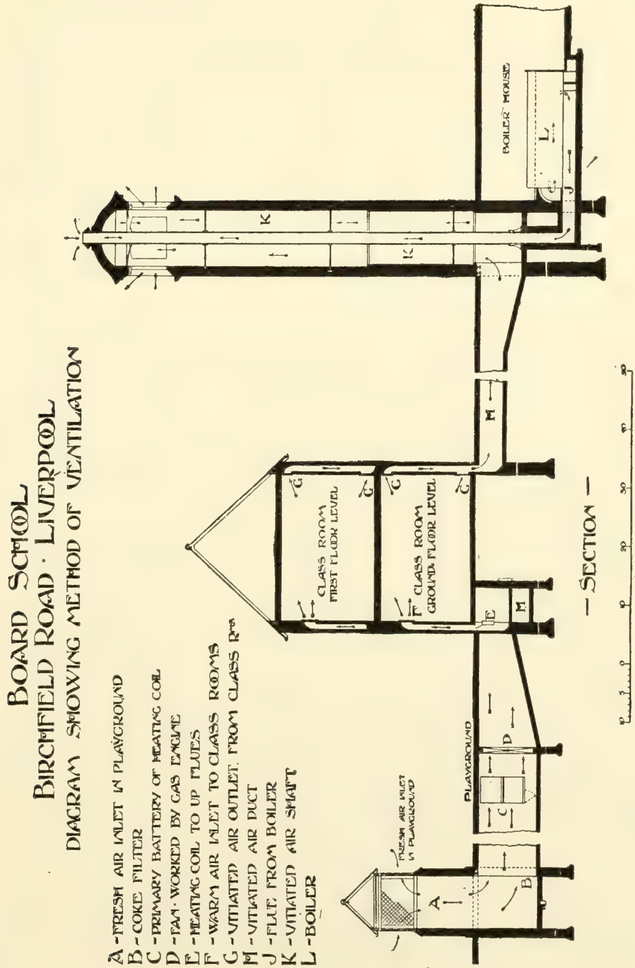

BOARD SCHOOL
BIRCHFIELD ROAD · LIVERPOOL
DIAGRAM SHOWING METHOD OF VENTILATION
A - FRESH AIR INLET IN PLAYGROUND
B - COKE FILTER
C - PRIMARY BATTERY OF HEATING COIL
D - FAN · WORKED BY GAS ENGINE
E - HEATING COIL TO UP FLUES
F - WARM AIR INLET TO CLASS ROOMS
G - VITIATED AIR OUTLET FROM CLASS R^ms
H - VITIATED AIR DUCT
J - FLUE FROM BOILER
K - VITIATED AIR SHAFT
L - BOILER
FRESH AIR INLET IN PLAYGROUND
PLAYGROUND
CLASS ROOM FIRST FLOOR LEVEL
CLASS ROOM GROUND FLOOR LEVEL
BOILER HOUSE
— SECTION —
SCALE OF FEET

FIG. 69.

the heat back to the teapot. In the case of a bright silver teapot, some heat would still be radiated, which is also arrested by the cosey. Under the same conditions, the tea would retain a higher temperature in the bright than in the dark pot in a given time. The aqueous vapour in the atmosphere absorbs a large amount of dark heat, but allows the light rays to pass with little diminution; the earth is thus warmed, but radiation of heat into space is prevented by the aqueous envelope. Glass, water, alum, and most transparent bodies, do not allow the dark heat rays to pass; but to this rule rock salt is an exception.

Specific Heat.—Under given conditions we may define specific heat as the quantity of heat required to raise the temperature of one pound of the substance by 1° C. The specific heat of a substance, as a rule, increases with rise of temperature; but platinum is an exception, as its specific heat varies very slightly with temperature, and it may thus be used for the measurement of high temperatures.

Thermal Capacity.—This is equal to the product of the specific heat and the density of the substance, and is the quantity of heat which is requisite to raise the temperature of unit volume of the substance by one degree.

Determination of Specific Heat.—Three methods are employed:—(1) The method of melting ice. (2) The method of mixtures. (3) The method of cooling.

The first method is performed by heating the substance to a certain temperature, and then placing it in a cavity formed in a block of ice provided with a cover of ice. When the body becomes cooled to zero, it is removed, wiped with a dry weighed sponge; which is also used to remove all the water in the cavity, and the sponge again weighed. Increase of weight equals weight of ice converted into water. To melt one pound of ice 80 thermal units are required. We have, therefore,

$$C = \frac{80P}{mt}.$$

The second method may be adopted for solids or liquids, the following formula being used—

$$c = \frac{m(\theta - t)}{M(T - \theta)}.$$

c = specific heat required. M = weight of body whose specific heat is required. m = weight of water. T = temperature of body. t = temperature of water. θ = resulting temperature.

Example— $$c = \frac{m20(22\theta - 20t)}{M4(130T - 22\theta)} = \cdot 0095.$$

The third method is performed by noting the time required by a substance in cooling from a given temperature. This method is not satisfactory for solids, but may be used with success for liquids.

Mr. Teale has laid down the following rules with regard to open fireplaces—

1. The use in their construction of as much fire-brick as possible.
2. The back and sides should be of fire-brick.
3. The back should lean or arch over the fire.
4. Deep from before backwards;—for a small room, at least 9 inches.
5. The slits in the grating should be narrow.
6. The front bars should be narrow.
7. The space under the grate should be closed in by a shield or "economiser," or a plate of iron put at the bottom of the fireplace within the grate.

Hospital wards should be heated by open fires, the radiant heat from which warms the walls and prevents the abstraction of heat by the walls from the bodies of the patients, which occurs when closed stoves are used. The passage of heat through different materials depends upon the conductivity of the material, its thickness, and the difference between the temperature on the inner heated surface and the outer or cooled surface.

The length of pipe required for Dwelling Rooms.—Twelve feet of 4-inch pipe for every 1000 cubic feet at 65° F.

The length of pipe required for Work Rooms.—Temperature, 50° to 58° F., six feet of 4-inch pipe per 1000 cubic feet.

The length of pipe required for School and Lecture Rooms.—55° to 58° F., six feet of 7-inch pipe per 1000 cubic feet.

Every square foot of glass will cool 1·279 cubic feet of air as many degrees per minute as the internal temperature of the room exceeds the temperature of the external air.

CHAPTER VI.

METEOROLOGY.

CLIMATE.

Climate (κλίμα, slope, inclination) may be said to embrace all those physical influences connected with the soil, heat of the atmosphere, or the water of a place, which, acting and reacting upon man, more or less materially affect him.

In considering the effects of climate on the inhabitants of a place, the following must be taken into consideration:—(1) The Density of the Population. (2) The Ages of the Living. (3) Occupation. (4) Differences of Food. Climate should also be considered separately in reference to the indigenous inhabitants and to strangers.

The severity of the climate on the coasts and in islands is diminished by the absorption during the summer by the sea of the sun's rays, which penetrate deeper into it than into the land. The sea, owing to its saltness, does not freeze so soon as fresh water; and imparting its heat to the winds that blow over its surface, affects the temperature of countries situated on its margins. The luxuriant vegetation of the countries bathed by the large expanse of ocean in the Southern hemisphere is strikingly contrasted with the barrenness of the land in the Northern, where, from excess of land, the air is rendered cold and dry.

Climate is divided into Continental, Insular or Sea, and Mixed Climate.

A *Continental* Climate consists in a cold winter and a hot summer.

An *Insular* Climate is characterised by a cool summer and mild winter.

A *Mixed* Climate is inclined to be *Continental* in winter and *Insular* in summer.

Asia is an example of the first, Europe of the second, and North America of the third.

Meteorology treats of atmospheric phenomena, more especially in relation to weather and climate.

Climate.—By climate are understood the combined effects upon atmospheric conditions of (1) temperature ; (2) pressure ; (3) moisture, and its precipitation as dew, fog, mist, cloud, rain ; (4) electrical phenomena ; (5) proximity to sea, and effects of ocean currents, elevation or other peculiarity of site.

Temperature.—The determination of the temperature of the atmosphere is made by a thermometer, an instrument consisting of a bulb and a long fine stem, containing either mercury for the measurement of high, or absolute alcohol for very low temperatures.

Thermometric Scales.

There are three thermometric scales in use, those of Fahrenheit, Réaumur, and Celsius, or the Centigrade. The Fahrenheit scale was invented by Fahrenheit in 1714, the higher point being that of boiling water ; the lower, the temperature of a mixture of equal weights of ammonium chloride and snow. The interval between the two points is divided into 180 degrees. The zero of Fahrenheit is 32 of its own degrees below freezing-point. In Réaumur's scale the interval between the lower and higher point is divided into 80 degrees ; in Celsius, into 100 degrees. To convert the three scales into one another, we have—

$$F = \frac{9C}{5} + 32 \qquad C = \frac{5(F-32)}{9} \qquad F = \frac{9R}{4} + 32$$

$$R = \frac{4(F-32)}{9} \qquad 5R = 4C.$$

Spirit thermometers are slower in their action than mercurial thermometers, owing to (*a*) larger size of bulb, and (*b*) greater thermal capacity of the liquid. Owing to the greater expansibility of spirit at high temperatures, the degrees of a spirit thermometer, when compared with a standard mercurial thermometer, will increase in volume in proceeding from the bottom to the top of the scale. For scientific accuracy, the tubes should be *calibrated* by passing a small quantity of mercury along the tube, and marking the length occupied by this

column in the different parts, allowance being made by the maker for these variations when he finally graduates the tube.

Of the thermometer there are two modifications—one being used to show the greatest heat, and known as the *maximum thermometer;* the other, the greatest cold, and known as the *minimum thermometer.* They may both be made self-registering.

In Rutherford's spirit minimum thermometer the index is entirely enveloped in the liquid; if the temperature rises the spirit will flow past the index without disturbing it, but if it falls the index is drawn back with the spirit by capillary attraction. The instrument is set by partially inverting it, until the index falls to the top of the spirit column; it is then placed in its horizontal position.

The minimum thermometer is read by noting the degree on the scale at which the end of the index farthest from the bulb is lying. To read it at the end *nearest* the spirit, is to give the temperature at the *time* of observation, not the lowest. In Rutherford's *maximum* thermometer, read the scale at the end of the index next the bulb. In the other *maximum* thermometers, read as for the minimum.

In the use of the thermometer, certain precautions are necessary. In spirit thermometers, a small portion of the spirit may evaporate and condense in the top of the tube, producing an error of from 3° to 8°. In the mercurial, even with the greatest care, a small quantity of air is not infrequently found at the top of the mercury, which, when heated, expands and causes the thermometer to register a few degrees lower than the actual temperature.

Solar Radiation Thermometer.—The object of this thermometer is to measure the amount of solar heat which arrives within our atmosphere. The instrument consists of a thermometer with a blackened bulb, enclosed in a glass case deprived of air. The bulb is blackened, because if a bright one were used much of the heat would be radiated away again. The thermometer is exposed to the sun, and placed 4 feet above the ground. It is made self-registering. The rules for reading it are:—

1. Note the maximum temperature which it registers.
2. Subtract from this the maximum temperature given by a thermometer in the shade.
3. The difference is set down as the greatest amount of solar radiation indicated during the day.

Terrestrial Radiation Thermometer.—A thermometer protected by a glass shield, placed a few inches above the ground. It is also made self-registering, and registers the degree of cooling by radiation from the ground.

Directions for taking Observations with the Thermometers when "Stevenson's Louvre Boarded Box" is used.

1. Let down the lid of the thermometer-box, and on no account touch the thermometers.
2. Read the dry and wet bulb thermometers first.
3. Read the minimum thermometer by noting the degree on the scale corresponding to the farthest end of the index from the bulb.
4. Read the maximum thermometer by noting the degree on the scale corresponding to the nearer end of the index to the bulb in Rutherford's thermometer.
5. In Negretti and Zambra's, or Phillips', read the scale at the end of the mercury farthest from the bulb.
6. Re-set the thermometers, and close the box.

The range of temperature will be affected by—

(*a*) *Height of Thermometers above the Ground.*—In all cases it would be as well to decide on a standard height for placing the thermometers, as the reading of two observers may differ from this cause alone. The nearer the ground the higher the temperature marked.
(*b*) *Degree of Direct or Indirect Radiation.*
(*c*) *Position of the Box.*—The nature of the soil, the covering of the ground—grass, sand, etc. Higher over long than short grass, higher over sand than grass, etc.
(*d*) *The Circulation of Air through the Box.*—Greater or lesser, according to the ventilation.

Causes of Interchange and Variation of Temperature.

By *Conduction*, *Convection*, and *Radiation*, an interchange of temperature among bodies heated to different degrees takes place, by which they undergo modifications of opposite kinds. The hottest grow cooler and the coldest grow warmer till a state of equilibrium is reached. At this point they are said to be of the same *temperature*. If they are again heated, the temperature is said to *rise*—if they become colder, to *fall*.

Conduction.—The communication of heat from particle to particle in the same body. It differs from radiation in—

(*a*) Being gradual and not instantaneous.
(*b*) It does not follow the law of rectilinear transmission, as the propagation of heat is as rapid along a twisted as through a straight bar.

Solids are better conductors than liquids, and liquids better than gases.

The practical inference from the above considerations is that dense soils are better conductors of heat than porous soils, the latter holding large quantities of air between the particles. Thus, loose soils are—

(*a*) Subject to higher temperatures.
(*b*) A greater degree of frost *near* the surface.
(*c*) The frost does not penetrate so deeply as in compact soils.

The knowledge of these facts would determine the depth for the laying of water pipes, etc.

Schübler, taking 100 as a standard, has arranged the absorbing power of certain soils for heat thus:—

Sand mixed with lime, 100; pure sand, 95·6; light clay, 79·9; heavy clay, 71·11; pure clay, 66·7; pure chalk, 61·8, etc.

Air charged with vapour, although it mitigates the heat of the solar rays, and retards the cooling of the earth by radiation at night, is a better absorber and better radiator than dry air. This accounts for the greater apparent coldness of the air at the breaking up of a frost than during the frost, the heat from our bodies being first absorbed and then radiated into space. Snow containing a large amount of air in the interstices of the flakes protects the ground from the invasion of the frost, and prevents the radiation of heat from the earth, thus helping to preserve the roots and bulbs of plants.

Convection.—The mode by which heat is transmitted through a fluid, depending on the alteration in the density of the particles, which causes them to rise from the bottom to the surface, or *vice versâ*. To convection are due the phenomenon known as "boiling," and the constant movement in the atmosphere to which we apply the term wind, and also the currents of the ocean. The heated particles of air at the surface of the earth rapidly rise, leaving a space into which the colder air from the poles flows, and wind is the result. Ocean currents are due to the same process.

Land and Sea Breezes.—When two neighbouring regions are

at different temperatures, a current of air flows from the warmer to the colder in the upper strata of the atmosphere; and in the lower strata a current flows from the colder to the warmer. Land and sea breezes are the result of this law, and may be thus explained. The land during the day becomes warmer than the ocean, and, imparting its heat by radiation to the superincumbent air, the warmed air rises to allow the colder air from the surface of the sea to take its place. During the night, the land and sea both grow colder, but the former more rapidly than the latter, owing to the high specific heat of water; and the relative temperatures of the two elements being now reversed, a breeze blowing from the land towards the sea is the result.

Radiation.—The propagation of heat from one body to another across an intervening space is known as radiation.

In meteorology we have to consider radiation under two heads—*solar radiation* and *terrestrial radiation.*

Solar Radiation.

The heat-rays from the sun falling on the land are arrested at the surface, the amount of absorption depending upon the conducting power of the soil, but on water the rays penetrate to a considerable depth below the surface.

Terrestrial Radiation.

1. Land.—The heat received by the earth is again radiated from it, and as a result of this alternate absorption and radiation, the mean temperature of the earth seldom varies. As soon as the sun disappears below the horizon, the earth begins to radiate heat into space, and thus to become chilled. This chilling proceeds slowly at first, but as the earth radiates more heat than it receives from the strata of air nearest to it, the chilling process becomes more rapid. This chilling is, however, soon arrested either by the return of the sun or by the action of the following causes:—

(*a*) The surface of the earth receives a certain amount of heat from the air in contact with it, and also by radiation downwards from the air above.

(*b*) The deposition of dew, by which a large amount of latent heat is set free.

(*c*) Clouds radiate back the heat to the earth. The loss of

heat from the earth is therefore less on cloudy nights, especially if the clouds hang low.

(*d*) The amount of vapour in the air also obstructs radiation; hence, the drier the air the colder the night.

(*e*) During calm nights, the earth is more rapidly cooled than when there is any wind. This may be accounted for by the fact that the earth comes in contact with the air of the upper as well as of the lower strata of the atmosphere, owing to the agitation caused by the wind.

2. WATER.—The radiation of heat from water is modified by the following causes:—

(*a*) Its great specific heat. It therefore cools more slowly than the land.

(*b*) The particles of water as they cool sink, allowing warmer portions to rise to the surface. This process of the sinking of the cold water and rising of the warm is very slow.

Thus, the temperature of the surface of water can only be lowered by the temperature of the whole mass falling, which will of course require a longer or shorter time, depending on the depth of the water.

As a result of the above, the temperature of the air on the surface of the water is not so quickly lowered as on the land. The temperature of the sea near the surface only varies on the average about 0·6° in the day, while on the land in Scotland the air varies 12° on the average (BUCHAN).

Hourly Variations of Temperature.—Due to the distance of the sun from the horizon, the temperature of a place varies from hour to hour. Twice in the day the temperature is at the mean, that is, between 9 and 10 A.M. and 9 and 10 P.M. The daily *minimum* occurs about an hour before sunrise, and the daily *maximum* about two hours after noon.

The mean temperature of a *day* is absolutely determined at Greenwich by marking the height of the thermometer every moment of the day by the aid of photography. This may also be roughly estimated in several ways:—

1. By taking the mean of the readings of the thermometer for every hour of the day.

2. By taking the mean of the maximum and minimum readings on the same day of the thermometer placed in the shade. The mean found by this plan is, however, a little greater than the true mean.

3. From the temperatures observed at the same hour day and night.

Thus the means of two observations at 8 A.M. and 8 P.M., 9 A.M. and 9 P.M., do not differ much from the true mean.

4. From three daily observations. The best hours for observation are 6 A.M., 2 P.M., and 9 P.M.

The highest temperature of a *day* is about an hour or two after noon—that is, at a time when the heat lost each instant by radiation is just equal to the amount of heat received from the sun.

The mean temperature of a *month* is found by dividing the sum of the daily means by the number of days.

The mean temperature of a *year* is found by adding together the monthly ranges, and dividing them by twelve.

The mean temperature of a *place* is determined by adding together the mean temperature for several months, and then dividing by the number of months during which the observations have been taken.

Temperature of a place is modified by :—

1. *Geographical Position.*—Temperature diminishes from the equator to the poles. On the eastern side of the Atlantic the mean temperature is greater than on the western side.
2. *Land and Water. Forests and Deserts.*
3. *Elevation above Sea-level.*—When the sky is clear, the fall in temperature, up to about 5000 feet, is 1° in 239 ; with a cloudy sky, 1° in 271 feet.
4. *Mountains and Valleys.*

Isothermal lines are lines drawn on a globe or a map through places having the same mean annual temperature. It must be borne in mind that isothermal lines only give us the *mean* temperature, not the actual variations of temperature ; for a country with a very cold winter and very hot summer may have a mean equal to that of a more equable climate.

Sunshine Recorders.—The duration and intensity of sunshine are recorded by Jordan's apparatus, which consists of a box constructed with a slit through which the sunshine falls upon revolving sensitised paper, leaving a photographic record.

Temperature increases with Height during Cold Weather—Why?

From the experiments of Glaisher and others, it is found that the temperature in cold weather at night is higher some feet above the ground than it is on the surface. The

mean temperature marked by the thermometer at 4 feet was 7° higher than the mean of the thermometer placed on *long grass.* This apparent contradiction to a well-known law, that the temperature *decreases with the height*, is found to depend largely on the physical configuration of the land, and is only marked in dry, clear, calm weather during winter. In windy, stormy weather, the ordinary law takes effect.

Take, for instance, an undulating country of hill and dale, with here and there portions of table-land. Terrestrial radiation, although present over the whole surface, will, however, in some parts, be modified in degree and intensity. Cold air, being denser than warm air, will tend to gravitate towards the valleys. The hot air from above, coming in contact with the chilled surface of the hill-side, will become chilled by contact with the cold surface and glide down the mountain-side. Thus, habitations situated on the slopes of hills have a higher mean temperature than those situated in the valleys. We also learn from this why fogs are more frequent in low-lying districts than over the higher ground. Plains and table-lands are not affected by the foregoing considerations. Of course, the lower we descend the colder will be the downward current of air, because it will be cooled in proportion to the extent of surface along which it has flowed.

The valleys, from this cause, act as reservoirs for the cold air gliding down the hill-sides. The currents of cold air will, like all other fluids, flow down the gorges and ravines where there is least resistance to their course. Hence, frosts are severe in valleys.

The foregoing statements will explain why Swiss villages, generally built on eminences rising out of the hill-sides, and bounded on both sides by gorges and ravines, are admirably protected from the cold of winter.

In choosing a health resort for invalids during the winter, the best places are those situated on gentle acclivities having a southern aspect, and well supplied with terraces, to permit of the enjoyment of outdoor exercise without the exertion of climbing up steep ascents. A flanking of trees above the station has also a beneficial effect.

Pressure of the Atmosphere.

The Barometer.—This instrument is founded on the well-known law, that *every surface exposed to the atmosphere sustains a normal pressure equal, on an average, to the weight of a column of mercury, whose base is the surface, and whose height is 30 inches.* The pressure of the atmosphere at the level of the sea is 14·7 lbs. to the square inch. Mercury is taken as a standard, for, other things being equal, the heights of columns of different liquids vary according to their densities; thus, taking the density of water as 1, and mercury 13·59, the column of water sustained would be 13·59 times as much; that is, 30 × 13·59 inches, or about 34 feet. A barometer 34 feet high would be most inconvenient. The space in the tube above the water is not a true vacuum, as it very nearly is in the mercurial barometer. The pressure on the water at the top of the tube, due to aqueous vapour, varies with the temperature, from half an inch at 32° to a foot at 75°. Mercury also gives off vapour, but the pressure is so slight that it need not be considered. The space between the mercury and the top of the tube is known as the *Torricellian vacuum.*

A barometer, in its simplest form, consists of a glass tube 33 inches long, closed at one end and open at the other, filled with pure mercury, and then inverted with its open end downwards in a vessel containing mercury, care being taken that no air be allowed to enter the tube. The tube thus filled, fixed in a vertical position to a graduated scale, forms the barometer in ordinary use.

The following are the precautions to be adopted in filling the barometer:—

1. *Purity of the Mercury.*—Purified by washing in dilute acid, and subsequent distillation. Impurity affects the density of the mercury, and also causes it to adhere to the sides of the tube.
2. *Perfect Dryness of the Tube.*—Any moisture rises as vapour to the top of the tube, forms an atmosphere, and depresses the mercury.
3. *The Mercury should be boiled to expel Air and Moisture.*—The mercury should be boiled in the tube in successive portions till full.
4. *The Tube should be 33 inches long, and of equal calibre.*

To test the Barometer, gently incline the tube, so that the mercury may strike against the closed end. A sharp metallic click will be heard if air be absent, a dull sound if it be present.

The foregoing is a description of the barometer in its simplest form; but for practical purposes, where great nicety is required, certain modifications are necessary.

The Syphon Barometer consists of a tube of equal calibre filled and bent in the form of a syphon, so that one leg is longer than the other, the long leg being closed, the short one open, the atmospheric pressure counterbalancing the extra weight of the longer column of mercury.

The Cistern Barometer consists of a tube, as before described, filled and inverted in a vessel containing mercury, the whole fixed to a scale. On this system Fortin's barometer is made, and the vessel or cistern has a leather bottom which, by means of a fine screw, can be raised or lowered until the surface touches a fixed ivory point.

Sources of error of the ordinary cistern barometer are—(1) Capillarity. (2) Capacity. (3) Temperature. (4) Height.

1. *Capillarity.*—The effect is to depress the column of mercury. This depression varies with the internal diameter of the tube—

$\frac{1}{2}$	inch	the error is	·003	inch.
$\frac{1}{3}$	,,	,,	·012	,,
$\frac{1}{8}$	,,	,,	·070	,,

To rectify this, an addition has to be made to the observed height, and special tables have been prepared for this purpose. Capillarity error is always additive. This error is only half as great when the mercury has been boiled in the tube as when this precaution has been neglected. The error increases with the diminished diameter of the tube.

2. *Capacity.*—This error is the result of the rising and falling of the mercury in the tube, and the consequent ever-varying level of the mercury in the cistern. The correction for this error is only necessary when no provision has been made for adjusting the mercury in the cistern to the zero point of the scale. The maker should mark the neutral point, and state the ratio of the interior area of the tube to that of the cistern—thus, *Capacity*, $\frac{1}{50}$. From these data the correction is made by taking a fiftieth part of the difference between the height read off and that of the neutral point, adding it to the reading when the column is higher, and subtracting it from the reading when it is lower, than the neutral

height. In barometers without the proper adjustment, there is a certain point on the scale at which the mercurial column stands when the mercury in the cistern is at the correct level. This is known as the *neutral point*. If any mercury be lost, or added, the neutral point is altered.

3. *Correction for the Temperature.*—This becomes necessary, as the mercury in the tube expands with heat, as does also the brass scale.

The following formula may be used to make this correction :—

h = observed height of barometer in inches.
t = temperature of attached thermometer.
m = expansion of mercury per degree—viz., ·0001001 of its length at 32°.
s = linear expansion of brass scale—viz., ·00001041, normal temperature being 62°.

$$\text{Correction} = -h\frac{m(t-32^\circ)-s(t-62^\circ)}{1+m(t-32^\circ)}.$$

Or the correction may be made by dividing by 9990 the difference between the observed temperature and 32°, and, as the temperature is above or below 32°, subtracting or adding the result to the observed height of the barometer.

4. *Correction for Height.*—As the density of the atmosphere diminishes as we ascend, it becomes necessary to make an addition to the barometric readings for every height above the level of the sea, the temperature at the time of the observation being noted, and the necessary correction made. If the air had everywhere the same density as at the level of the sea, the problem would be very easy; but it is found that the density diminishes very rapidly as we ascend—in fact, *as the heights increase in arithmetical progression, the pressures diminish in geometrical progression.*

In the syphon barometer the errors of capillarity and capacity do not exist, but it labours under the following disadvantages :—That the height of the mercury in the long and in the short arm has to be observed, complicating matters by admitting a considerable error in the two readings; and also that the mercury in the short arm is exposed to the air, and may thereby suffer contamination from dust and moisture.

The Ordinary Weather-Glass, or Wheel Barometer, is a

syphon barometer fixed in a frame. On the mercury in the short arm a float is placed, to which a string is attached which is passed over a spindle, and kept tense by a small weight. As the mercury rises or falls the float rises or falls also, and thus a backward and forward motion is communicated to the spindle, causing the index attached to point to "fine," "wet," "dry," etc., marked on the dial. The drawbacks to this instrument are connected with the amount of friction of the additional apparatus. These barometers or weather-glasses are of little use for scientific purposes; for it is not so much the *absolute* height, as the actual rising and falling of the mercury, which determines the kind of weather likely to follow. Cold dry air is the heaviest and warm moist air the lightest possible arrangement. Thus, in this country, a south-west wind generally brings rain and a falling barometer, and a north-east wind fine weather and a rising barometer. One volume, 11·2 litres of air, weighs 14·4 grammes, and one of watery vapour only 9 grammes. The watery vapour in the air is in reality *water in a gaseous state*, and not vapour as we see it in visible steam.

THE VERNIER.—This instrument is used for measuring the fractions of a unit of length on any scale. Used with the barometer, ten divisions of the vernier are equal to eleven on the barometer scale; and as these ten are all equal to each other, it follows that each division of the vernier must be equal to $1\frac{1}{10}$ division of the barometer scale, or $\frac{11}{100}$ inch. If, therefore, any division of the vernier coincide, or is in a line with a division on the scale, the lines immediately above or below those which coincide will be separated by a distance exactly equal to $\frac{1}{100}$ inch; the next two divisions either way will have a deviation of $\frac{2}{100}$ of an inch, and so on. To use the vernier, we first notice the height of the mercury column by the fixed scale, which we find to be more than 29·5 inches, but less than 29·6; we then place the zero, or top of the vernier scale, on a level with the top of the mercury. We may then observe, for instance, that only one of the lines of the vernier coincides with a line on the scale, and this line is that marked 6 on the vernier. Now, as from the top of the mercury to these lines which coincide, there are six which do not, and as each pair deviates by $\frac{1}{100}$ of an inch more than the pair below it, the top pair must deviate by the $\frac{6}{100}$ of an inch. Hence we get the reading of the mercury, which is 29·5 inches and

$\frac{6}{100}$ of an inch, or 29·56. The vernier is, of course, movable along the barometric scale.

The Aneroid Barometer.—The principle of action of every aneroid barometer is that of measuring by pressure upon a vacuum chamber the weight of the atmosphere above the instrument at the time of making an observation. This pressure on the metal box is communicated from the box by a series of springs to an index traversing a graduated scale. For this reason, when we apply the instrument to the measurement of altitudes, we have to encounter the difficulty of a continual change that is going on in the atmosphere at any given station, by the effects of moisture and wind; therefore, a scale of heights placed upon the aneroid can only give a scale of *differences of heights* for one given pressure. Nevertheless, with care, very accurate results may be obtained.

Variations of the Barometer.—These may be divided into periodic and non-periodic or irregular. The diurnal is the most marked of the periodical variations, and is most regular in the tropics. "Their regularity is such that, in the daytime especially, we may infer the hour from the height of the column of mercury, without being in error on an average more than fifteen or seventeen minutes" (Humboldt's *Cosmos*). On the other hand, the barometer is almost constantly in motion in the middle latitudes, so that the periodical movements can only be detected by taking the mean of a long series of observations.

Influence of Temperature and Vapour on the Barometer.—The barometric pressure of the atmosphere depends to a great extent upon temperature and hygrometric condition. When air is heated it expands in volume, and becomes diminished proportionally in density. When the vapour of water is added to air the effect of heat is also to expand the mixture and reduce its density. These two causes combined produce certain diurnal variations of atmospheric pressure, which are indicated by two maxima and two minima of the barometric column. The maxima pressures are found to occur about 10 A.M. and 10 P.M., and the minima about 4 P.M. and 4 A.M. It is observed, however, that the maximum at 10 A.M. is greater than that at 10 P.M., and that the minimum at 4 P.M. is more marked than that at 4 A.M.

Influence of Sea and Land.—It appears from observation, that during the month of July in the northern hemisphere the lowest pressures are distributed over continents, the depression being greater the larger the continental mass, and that it is over the ocean that the highest pressures prevail, especially over those parts which are for the most part landlocked.

Low Pressure in the Northern Hemisphere over Continents.—This low pressure is the result of the more rapid heating of the land as compared with the ocean, owing to the greater specific heat of the latter. The air, quickly heated by radiation from the land, rises and overflows, diminishing the pressure near the surface of the land. The frequent precipitation of vapour in the form of snow, as before shown, by letting free a large amount of latent heat, also lowers the pressure, upward currents of air being produced. The low pressure over Asia amounts to nearly half an inch.

High Pressure over Ocean in Southern Hemisphere.—During the same season the pressure in the southern hemisphere is increased, for the hot air, rising from the northern continents, flows over in the higher regions of the atmosphere southwards, and proportionally increases the barometric pressure there as it sinks and flows over the southern oceans. The like takes place over the oceans of the northern hemisphere; hence we find that the increase of pressure is most marked in the North Atlantic, due to its being more or less surrounded by land supplying *overflow* air from both sides.

In January, the whole of the preceding results are reversed.

Cause for this.—The land rapidly parts with its heat; on the other hand, the sea, owing to the greater specific heat of water, slowly cools; hence, there is a constant current of warm air continually rising from its surface in winter, flowing over and becoming piled up over the land. The barometer is lowest over the land in the hemisphere where summer prevails, and highest in that where winter prevails, this effect being due, to a great extent, to the annual range of the thermometer.

Elevation above the Level of the Sea.—When a barometer is elevated above the level of the sea, the column of mercury sinks, due to the diminished weight of the air; for as we rise in the atmosphere, the density of the air is lessened. Due to this fact, elevations above the sea-level may be calculated—a

fall of one inch in the barometer indicating an elevation of 872 feet.

Areas of Equal Pressure.—These are joined together by lines called *isobarometric lines*, or simply *isobars*, that is, lines of *equal pressure.*

The Use of the Barometer in Mines.—It appears that "when the barometer indicates a fall, the thermometer a rise, and the wind from the E.S.E. or south (in England), an ordinarily fiery colliery will be certain to pass rapidly into a state of great danger. The fall of the barometer is a sure presage of increasing discharge of inflammable gas; for when the barometer stands steadily—say at 29°—and the pressure is uniform, nothing exudes but the ordinary 'makings' of the mine; but when a sudden fall of the barometer portends a lightening of the atmosphere, and consequently a pressure upon the orifices whence the gas escapes, or upon the main body accumulated in the waste, then it is that extraordinary eruptions take place, enough to overpower and adulterate even the main current of air, and consequently to subject the mine to explosion."

Influence of Barometric Pressure on Sewers.—The lowering of barometric pressure causes an escape of the sewer gases pent up in the sewage, whereas an increase of pressure acts in a contrary manner, confining, as it were, the gases in the sewage.

Winds.

Wind is air in motion. Three causes are at work in the production of wind:—

1. Unequal atmospheric pressure. Winds blow from a region of higher to a region of lower pressure. In other words, cold air is heavier than hot air; hence, temperature is the cause of wind.

2. Unequal specific gravity of the atmosphere. The result of temperature and humidity.

3. The rotation of the earth.

The rotation of the earth would not alone produce wind, but it materially affects the currents of air flowing towards the equator from the north and south poles, and drives the air in a line the resultant of the two forces, the rotation of the earth and the flow of air from the poles to the equator

respectively, N.E. on the north of the equator, and S.E. south of the line. The Trade winds are the result of the above causes, and extend from 7° to 29° N. for the N.E. Trades, and to latitude 20° S. for the S.E. Trades. Between these, on both sides of the equator, there is a belt of from 150 to 500 miles of calm or variable winds.

THE EAST WINDS OF BRITAIN.—These blow chiefly during spring. They may result from the following causes:—

1. Expansion of the air in the southern hemisphere when the sun is south of the equator, and its overflow to the northern hemisphere.
2. Hence, a greater accumulation of dry air north of the equator in winter than in summer, the result of precipitation of snow, etc.
3. The high atmospheric pressure due to the low temperature over Russia in winter, as compared with the summer pressure.
4. The heating of the north of Africa and south of Europe and Asia causing the surface air to rise, with a consequent rush of air from Russia to take its place.
5. A tributary from this northerly current constitutes our east winds.

The unhealthiness of these winds is due, to a great extent, to their coldness and dryness, and want of ozone. Radiation is much more active when the air is dry than when it is moist, and therefore our bodies radiate more heat when a dry cold air is blowing over us than when the air is more or less charged with vapour; and we, therefore, feel the cold biting east wind, which robs us as rapidly of our heat as it is generated, whilst that portion of our bodies which is exposed to the sun is almost scorched. This comparative freedom from vapour also explains the intense heat of the direct solar rays in the polar regions, where Captain Scoresby noticed that the pitch rapidly melted on the side of his vessel exposed to the sun, whilst ice was as rapidly produced on the protected side. To like causes may be attributed the intense solar heat in Alpine regions, and the oppression felt in travelling under these conditions.

Monsoons—Cause, Effect on Climate, etc.—These are due to the modifying influence of land on the atmospheric changes before described, and which, in this case, so affects the Trade winds as to change the direction of their course for certain

months in the year. Thus, from April to October, the prevailing winds blow from S.W.; from October to April, from N.E. This is due to the fact that during summer the southern part of Asia becomes warmer than the Indian Ocean near the equator, and thus draws the air towards it, which, coming from a lower latitude, has an excess of motion towards the east, and this, combined with the motion from the south, due to the influence of heat, produces a wind from the S.W. During the winter the reverse takes place; the ocean being warmer than the land, the usual N.E. Trade is the result. The velocity of wind varies with the latitude, decreasing in velocity from the equator to the poles. This fact will help partly to explain the increased velocity of the monsoons.

The effect of the S.W. monsoon on the climate of Southern Asia, and on Central and Western India, is most marked; for the vapour with which it is charged is condensed by the high mountains, producing heavy rains, and an increased buoyancy in the air by the heat liberated in the act of condensation, thus lowering the density of the lowest strata and increasing the velocity of the inrushing air. This and the before-mentioned causes explain the terrible velocity of the monsoon. The rainfall in China, from this cause, amounts to 3·34 inches in winter, and 37·70 in summer. A knowledge of the direction of these winds is also valuable as a means of intercommunication by sailing ships.

Cyclones are storms in which the motion of the wind is found to be in great circuits spirally inward toward the centre of the storm. Cyclones on an average travel at the rate of 18 miles an hour, and as a rule follow the course of the prevailing winds. Cyclones are announced by a rapid fall in the barometer, especially in the centre of the storm, where the wind is most violent; but as the centre itself passes over any spot, a momentary calm is observed, the wind immediately recommencing in the reverse direction to that which it had the instant before—anti-cyclone—a necessary consequence of the vorticose motion. In the anti-cyclone the highest pressure is found in the centre of the storm, and *decreases* towards the circumference. These storms, associated with warm sultry weather in summer and frost and fogs in winter, generally remain in the region in which they are formed; but the two systems, cyclone and anti-cyclone, are always in close proximity

to one another. The direction of the wind in a cyclone is in a spiral form towards the centre; in the anti-cyclone from the centre.

Force and Direction of the Wind.—To determine the force and direction of the wind various forms of anemoscopes and anemometers are used. These are all modifications of the common vane, to which certain rackwork adjustments are added, and by the aid of which the force and direction of the wind may be registered. Those best known are Robinson's and Osler's anemometers; the latter registers direction, velocity, and pressure.

To calculate Force of Wind.—Multiply the velocity for a minute by 60; square the result, and multiply by ·005. The result will give the force of the wind in pounds, or parts of a pound, per square foot.

The Velocity of the Wind.—The average velocity of the wind may be taken as 9 miles an hour at Plymouth, 10 miles at Greenwich, and so on—varying with the locality. Several tables of comparison for the velocity of wind—from *just perceptible* at 2 miles, to a *hurricane* at 84 or 100 miles an hour—have been made. Beaufort's scale is as follows:—

Force.	Beaufort Scale.	Miles per Hour.
0	Calm	Up to 3
1	Light air	8
2	Light breeze	13
3	Gentle breeze	18
4	Moderate breeze	23
5	Fresh breeze	28
6	Strong breeze	34
7	Moderate gale	40
8	Fresh gale	48
9	Strong gale	56
10	Whole gale	65
11	Storm	75
12	Hurricane	90

Influence of Trees, Forests, and Sandy Deserts.

Luxuriant vegetation and dense forests act by preventing the heating of the ground by the direct rays of the sun, and also by the rapid absorption of solar heat by the moisture, the

result of the vital organic action of the leaves. Due also to the increased radiation from the greater exposed surface of the leaves, the amount of heat accumulated on the surface of plants is less than that of the unprotected land. Thus, vegetation acts in a threefold manner, by *shade*, *evaporation*, and *radiation*. Trees part with their heat from above downwards, and those leaves are first cooled which are directed without any intervening screen towards the unclouded sky. A second stratum of leaves has its upper surface turned to the under surface of the first stratum, and will give out more heat by radiation towards that stratum than it can receive by radiation from it. The result of this unequal exchange will thus be a loss of temperature for the second stratum of leaves also. By this process, "a tree, the horizontal section of whose summit would measure, for example, 2000 square feet, would act in diminishing the temperature of the air equivalently to a space of bare or turf-covered ground several thousand times greater than 2000 square feet." Another effect of forests is the greater distribution of heat over the twenty-four hours in countries where the ground is thus protected, than in those where sandy deserts are exposed to the direct action of the sun. Trees, though following the same laws as other bodies as regards heating and cooling by solar and nocturnal radiation, do not, however, appear to reach their maximum of temperature till a short time after sunset. This in summer occurs about 9 P.M., while the maximum temperature in the air occurs between 2 and 3 P.M. (BUCHAN). For the reasons just stated, the change in the temperature of trees is slower than in the air, as stratum after stratum of leaves has to part gradually with its heat. The result of this transference of the maximum daily temperature to so late in the evening is to render the nights warmer and the days cooler, thus more nearly approaching an insular climate. It is also not improbable that forests, whilst diminishing evaporation from the damp ground under them, increase the humidity of the atmosphere; and it has been shown that in order to form one pound of woody fibre a plant evaporates 200 lbs. of water. The roots of trees also tend to retain the moisture in the soil. The heat of summer is lowered, and the cold of winter lessened, by the presence of large forests. Having a lower temperature than that of the surrounding district, forests increase the rainfall, and thus act like mountains in

arresting the rain, bringing clouds and condensing their vapour into rain.

Vegetation is also a source from which the atmosphere obtains its electricity. Oxygen, charged with negative electricity, is given off by plants during the day; and carbonic acid, charged with positive electricity, during the night; the two probably neutralise each other.

From the above considerations, and from the fact that the movement of air is materially affected by forests, care should be taken to keep the growth of trees within proper limits. Stations situated in the midst of dense forests are often very unhealthy. But, on the other hand, it must be remembered that trees have a wonderful power in arresting the spread of malaria; villages separated by trees from marshes do not, as a rule, suffer from malarious diseases. Trees also protect mountain stations from descending currents of cold air.

From a hygienic point of view, Parkes divides vegetation into Herbage, Brushwood, and Trees.

Herbage is always healthy, cooling the ground, as before noticed.

Brushwood is generally unhealthy, and should be removed, as the air is almost stagnant where the underwood is very thick. The removal should be effected in the middle of the day, when the sun is hottest. The removal of brushwood *may*, however, for a time give rise to malarious diseases.

Trees should be removed with care, and in most cases only when they materially affect the proper movement of the air, as their injudicious removal might materially affect the rainfall and the supply of water. The waters of Lake Tacarigua, which were gradually receding towards the end of last century, are now increasing, due to the presence of large forests which have sprung up since the destruction by war of the peaceful operations of agriculture in the valley Aragua in Venezuela, in which the lake is situated.

Sandy Deserts.—Due to the absence of vegetation, the temperature of sandy deserts frequently rises to 120°, 140°, or even 200°. The desert of Sahara gives to the south of Europe an unduly high temperature.

Influence of Lakes, Marshes, and Rivers.

Lakes.—The presence of large masses of deep water surrounded by land, as is the case in North America, results in an almost insular climate in summer, and a continental one in winter; for the frozen lakes seem to exercise the same influence as if they were solid land. The specific heat of water helps, therefore, to lower the summer temperature; but the winter ice gives the same results as an equal mass of land. Deep lakes situated at the bottom of valleys are a source of heat in winter, for the cold air coming down the mountain-sides cools the surface water, which sinks deep into the lake, thus scarcely affecting the temperature at the surface. The severity of the winters of the countries surrounding the Baltic is due to the shallowness and feeble saltness of that sea, which causes it to be so easily frozen over.

Marshes, on the other hand, by the evaporation of the thin layer of water, help to keep down the summer temperature. Marshes have a marked tendency to render the surrounding country unhealthy. Ague and remittent fevers are attributed to the presence of marshes in the south of Essex and at the mouths of many of the African rivers. The presence of mosquitos, which breed in swampy places, explains this.

Rivers add largely to the moisture in the atmosphere, and, therefore, modify the climate of a place. They also partly affect the geological configuration of a country. In tidal rivers the banks are frequently very unhealthy, especially if the country through which they flow is low and subject to irregular inundations. In some rivers a peculiar phenomenon is often witnessed known as the "bore." To explain the phenomenon as seen in the Severn, which is a tidal river, it must be borne in mind that the ordinary tidal wave in the ocean is an oscillatory wave and not a wave of translation, but if the tidal wave rolls into a narrow estuary, the water becomes heaped up and causes a sudden rush into the channel of a river, producing the "bore." Thus the tidal wave becomes a wave of translation.

Influence of the Sea.

In considering the effect produced by the sea on the climate of a place, we have to consider—

1. *The great Specific Heat of Water.*—Water has the greatest thermal capacity for heat of all known substances. This property of water prevents the surface of the sea from being as highly heated as the land, and also retards its cooling, at the same time that it gives out more heat through a given range of temperature than the land. The amount of heat required to raise one pound of water from 0° to 100° C. would raise the same weight of iron from 0° to 900° C.; hence, a pound of water, on cooling from boiling point to zero, gives out 900 caloric units.

2. *Density.*—Water follows the law that bodies expand when heated, and contract on being cooled, till a temperature of 39° F. or 4° C. is reached, when it is at its greatest density, and from which it then begins to expand till the freezing point is reached. Water sinks on cooling, and this sinking of the cold and rising of the warm continues till the whole mass of water has fallen to 4° C. or 39° F., when further motion is arrested, and needles of ice are formed at the surface, while the temperature at the bottom remains at 4° C. or 39° F. Now, while this holds good for fresh water, certain modifications have to be considered when the water contains salt or any other saline substance. Depending on the saltness of the water, the temperature of maximum density falls with and below the freezing point, and salt water then follows the law of expansion and contraction by heat and cold. An important fact to be deduced from these considerations is, that no ice can be formed on the surface of salt water till the temperature of the whole mass has fallen to its freezing point; but in the case of fresh water, as we have just seen, ice is formed as soon as the temperature of the mass reaches 4° C. or 39° F. The temperature of the bottom of the sea has been determined by sinking registering thermometers enclosed in strong cases to prevent their being broken by the immense pressure to which they are subjected.

3. *Currents.*—The climate of a country is more or less modified by the temperature of the sea currents which bathe its shores.

The temperature of the following countries is raised—West of Europe, East of Africa, South Asia; these depressed—East and West Coasts of North America, West Coast of South America, West Coast of Africa, East Coast of Asia, and South Coast of Australia.

The sea currents depend on the following causes:—

1. The duration and strength of prevailing winds.
2. The propagation of the tide-wave round the globe.
3. Variations of density due to changes of temperature in different latitudes, and to the relative quantity of saline contents.
4. Variations of atmospheric pressure regular in the tropics, and propagated east and west.

Of ocean currents, the most important to us in Europe is the Gulf Stream. It is, in fact, a great shallow river in the ocean, the margins of which are so well defined that Admiral Sir Alexander Milne found that the temperature at the bow of his vessel was 21·5° C.; at the stern 4·5° C.

The practical effect on the climate of Britain of a large stream of warm water flowing along its western coast is to raise the temperature 20° higher than it would otherwise have been.

Influence of Hills and Mountains.

In order to give some idea, on a map, of the evenness or unevenness of a country, several methods have been adopted. One method is that known as *hill shading*, the lines or *hachures* being drawn thickly and closely together; the objection to this plan is that, although it shows that one portion of the country is higher than another, it does not enable us to determine the relative heights. The other method by *contour lines* is at once more scientific and accurate. Contour lines are lines drawn through all places which are at the same height above the level of the sea. It will, however, be thus seen that contour lines may be used whenever we wish to depict differences in temperature, pressure, magnetic variation, etc., known as *isothermals*, *isobars*, etc.

Contour lines are often formed by the subsidence of water in a lake, as in the case of the parallel roads of Glen Roy. By the use of these lines, we may show the *water-shed* of a district on a map. The term *water-shed* is used to denote the slope along which the water flows to form a river or lake; and *water-parting*, the summit of the slope. The summit of the Cotswold Hills thus forms the *water-parting* between the *water-sheds* of the Thames and Severn. The "*crest of the water-shed*," or "the *summit of drainage*," may also be used for "*the water-parting*."

The sea-area on a map is marked by figures, or *Soundings*—a rough method when compared with the use of contour lines.

Mountain ranges act by precipitating the moisture from the winds which blow over them; thus, one side of a lofty mountain range may have a moist, humid climate, whilst on the other side, the air being thus previously dried, the winters are cold and the summers hot and sultry. The probable explanation of this is, that, on the one side, the ground is protected from excessive solar and terrestrial radiation by the moisture suspended in the air; on the other side, this protecting envelope is wanting. The westerly winds which sweep over the Rocky Mountains deposit most of their moisture on the western slopes, and when they descend the eastern sides, are so dry and cold that ordinary agricultural products require artificial irrigation to raise them; as seen in a large portion of the North-West Territories of Canada, and the Western States of America. In Peru, this effect is most marked, where a barren table-land some miles in area, known as Punos, is the result of the protecting power of the Andes. Prescott states that the ancient Peruvians preserved the bodies of their dead by simply exposing them to the cold dry air of the mountain. The great Desert of Gobi is caused by the Himalaya Mountains. Mountains collecting moisture from the clouds increase the rainfall, and thus produce the streams of water which flow down their declivities. The rainfall near Ben Lomond measures 91 inches.

In hot climates, the plains at the foot of lofty mountains are often most unhealthy; but the cold air rolling down the sides of snow-capped mountains renders the valleys at their base cool and pleasant. This is most strikingly noticed on the Italian side of the Alps, and also on the plains of Granada, where the cold air from the Sierra Nevada lessens the excessive heat of a Spanish summer. In selecting a mountain station for troops, the direction of the prevailing winds should be considered for the reasons above given.

The Influence of Drainage on Climate.

The beneficial effects of the drainage of the land, apart of course from sewerage, are sometimes as great as if the land had been transported 100 or 150 miles southwards (Buchan). This is due to the fact that 1 grain of water in being evaporated

takes off sufficient heat to raise 960 grains 1° F., the heat becoming latent. As in well-drained land there is less water to evaporate, the soil becomes warmer.

Hygrometric State of Atmosphere.

The normal constitution of the atmosphere consists of a mixture of oxygen, nitrogen, and aqueous vapour, with traces of carbonic acid. The amount of aqueous vapour depends upon the temperature and pressure of the atmosphere, but the proportions of the gases present are nearly the same everywhere.

Humidity.—This term is held to imply the amount of vapour present in the air, and also the ratio of this to the amount which would saturate the air at the actual temperature. The amount of vapour in the air is not a measure of its humidity, for the air is for the most part drier in summer than in winter, although the amount of vapour present is much greater. The vapour also, like the temperature, decreases as we ascend, but the rate of diminution of vapour is more rapid than that of the temperature. The vapour in the air acts in two ways: it moderates the heat of the sun, and also prevents the radiation of heat from the earth into space. According to Tyndall, a sheet of vapour, being in a great measure impervious to heat, acts as a screen to the earth.

By *Relative Humidity* is understood the percentage of moisture in the atmosphere, complete saturation being taken as 100.

By *Absolute Humidity* is understood the actual amount of moisture in a given quantity of air.

Tension of Aqueous Vapour is expressed in inches of mercury, being the elastic force of vapour in the atmosphere.

Instruments used for finding the Humidity of the Air:—

1. Hygrometers of Absorption, or Hygroscopes.
2. Condensing Hygrometers, or Dew Point Instruments.
3. Psychrometers, Hygrometers of Evaporation, or Wet and Dry Bulb Thermometers.

Another division of these instruments is into *direct* or *indirect* hygrometers, thus—

Direct.—Leroy, Daniel, Regnault, and Dines' hygrometers.
Indirect.—Saussure's hygroscope; the dry and wet bulb hygrometer.

1. Hygrometers of Absorption, or Hygroscopes.

These instruments depend upon the fact that all organic substances are affected by moisture, which generally increases their dimensions. The hair hygrometer, or rather *Hygroscope*, of Saussure is a very imperfect instrument, as much depends on the previous preparation of the hair, and the length of time it has been in use. This instrument consists in an oblong frame, to the top of which one end of a hair is attached, the other end being fixed to an axle, carrying an index. By the shortening or lengthening of the hair acting on the axle, the index is made to move along a graduated arc.

2. Condensing Hygrometers, or Dew Point Instruments.

Leroy's Hygrometer.—The simplest instrument of the kind consists of a bright tin vessel filled with water artificially cooled, and having a thermometer immersed in the water. A deposit of moisture forms on the sides of the vessel when the temperature of the water falls below the dew point of the surrounding air. The deposition of dew does not, however, begin till the point of saturation has been passed: the indication of the thermometer is, therefore, slightly too low. Besides this objection, there is another of more importance: the placing of a vessel of water open to the air in the very place where the humidity of the air is required to be determined.

Daniel's Hygrometer.—A straight glass tube, supported on a stand, with a bulb at each end, at right angles to the straight part. One of the bulbs contains pure ether, over which a thermometer is suspended; the other bulb contains the vapour of the ether, and is covered by a piece of thin muslin. To use the instrument, the muslin is wetted with ether; this causes a condensation of the ether vapour, giving rise to an increase of evaporation of ether from the naked bulb, producing a commensurate decrease of temperature. The temperature at the moment of the deposit of moisture on the ether bulb is noticed, and is found to be a little lower than the dew point. If, however, the instrument be then left alone, and

the temperature noted at the moment of the disappearance of the dew, the mean of the two readings will give the correct dew point. A thermometer is generally attached to the stand, and gives the temperature of the adjacent air. On account of the boiling point of ether being 36° C. (97° F.), this hygrometer cannot be used in very hot climates.

Regnault's Hygrometer.—A modification of the foregoing, but more accurate in its results. It consists of two thin glass tubes, A and B, corked at one end, and fitted into two thin silver thimbles, suspended on a stand. A thermometer is placed in each, the stems of which pass through the corks. The tube A contains some ether, and a glass tube opening below the ether passes through the cork, and is open to the air. The tube A is connected with an aspirator. The instrument is thus used: the cock of the aspirator is turned on, air is drawn through A, and the temperature noted the moment the silver thimble becomes tarnished with moisture. The thermometer in B gives the temperature of the air, that in A the temperature of the dew point.

Dines' Hygrometer.—A glass vessel connected with a pipe at the bottom, which is placed close under a plate of black glass. A thermometer is so arranged that, when a stop-cock is opened, the cold ice water flowing from the vessel may cool the glass, and also surround the bulb of the thermometer. The glass plate soon becomes dulled, and the thermometer is read. The water is now turned off, and as soon as the glass becomes bright the thermometer is again read. The appearance and disappearance of the dullness marks the dew point. This instrument is very useful in determining the amount of moisture in a room.

3. Psychrometers, Hygrometers of Evaporation, etc.

This instrument, the *dry and wet bulb hygrometer*, consists of two identical thermometers placed at a short distance from each other on a stand, the bulb of one being free, whilst the bulb of the other is covered with a piece of muslin, kept moistened with water by means of a cotton wick leading from a vessel containing water. The depression in the muslin-covered thermometer only measures the *evaporating* power of the air, but as this depends on the amount of moisture present in the air, the wet bulb thermometer indirectly measures the

humidity of the air. The greatest objection to the use of this instrument is that during frost it is impossible to get reliable indications from it. It is, however, useful in hospital wards for determining the amount of moisture present in the air.

Precautions to be observed in using this instrument :—

1. Free circulation of air round the wet bulb must be maintained.
2. The vessel containing the water should be small, and placed some inches from both bulbs.
3. The muslin must be kept thoroughly moist, but not allowing a collection of water at the bottom of the bulb.
4. When the wick is frozen in winter, the bulb must be dipped in water, and time allowed for the water on the bulb to freeze before an observation is made.
5. Both thermometers must be exactly alike. To use this instrument, take the difference between the dry and wet bulb, and multiply it by the factor given in Glaisher's Tables standing opposite the *dry* bulb temperature ; deduct the product from the *dry* bulb temperature ; the result is the dew point.

The following incomplete Table will show how the above is calculated out :—

GLAISHER'S FACTORS.

Dry Bulb Therm.	Factor.	Dry Bulb Therm.	Factor.	Dry Bulb Therm.	Factor.
10	8·78	21	7·88	32	3·32
11	8·78	22	7·60	33	3·01
12	8·78	23	7·28	34	2·77
13	8·77	24	6·92	35	2·60
14	8·76	25	6·53	36	2·50
15	8·75	26	6·08	37	2·42
16	8·70	27	5·61	38	2·36
17	8·62	28	5·12	39	2·32
18	8·50	29	4·63	40	2·29
19	8·34	30	4·15	41	2·21
20	8·14	31	3·70	42	2·23

Example—

$$\text{Dry Bulb} = 40°.$$
$$\text{Wet Bulb} = 36°.$$
$$40° - 36° = 4° \times 2{\cdot}29° = 9{\cdot}16°.$$
$$40° - 9{\cdot}16° = 30{\cdot}84°.$$

Apjohn's formula for calculating the tension of aqueous vapour at the dew point temperature :—

$$F = f - \frac{d}{88} \times \frac{h}{30} \text{ or } F = f - \frac{d}{96} \times \frac{h}{30}.$$

d = the difference of wet and dry bulb thermometers in Fahrenheit degrees.
h = barometric height in *inches.*
f = the tension of vapour for the temperature of the *wet bulb.*
F = elastic force of vapour at dew point.

The constant 88 is used when the reading of the wet bulb is above 32° F., and 96 when it is below.

Dew.—Dr. Wells first gave a correct explanation as to the cause of dew. He showed that when, as the result of radiation, objects near the earth's surface became cooled down to a certain point, a deposit of moisture formed on them. This is *dew*, and it plays an important *rôle* in the economy of nature besides merely supplying water to plants, in which it performs the functions of rain. The deposition of dew produces enough heat to protect plants from a considerable degree of cold. In fact, a single gramme of water vapour condensed on a plant furnishes sufficient heat to raise 500 grammes of water one degree, and to raise the temperature of the plant itself eight degrees, if we suppose the plant to weigh 75 grammes (E. Bouant). No wonder then that the poets have called flowers "the daughters of the sun and of the dew." "It is dew," says M. Jamin, "that protects the earth from the visitations of frost; it is by this beneficent phenomenon that plants are protected from freezing, by returning to the air the vapour which they have in reserve and the heat which they have caught; then when the sun appears in the morning, his first duty will be to convert the dew into vapour and store up afresh the heat which has been dissipated."

Circumstances Favourable to Formation of Dew.

1. *A cloudless night and free exposure to the sky.*—Clouds, by reflecting back the heat radiated from the earth, prevent the deposition of dew.
2. *A nearly tranquil atmosphere.*—Wind, by producing an interchange of air of varying temperatures, prevents sufficient depression of temperature, and therefore arrests the formation of dew.
3. *An atmosphere charged with moisture.*
4. *Good radiators and bad conductors.*

Good radiators and bad conductors—Wool, hare-skin, glass, etc. Dew freely formed.
Good conductors and bad radiators—Metals, etc.—Dew formed with difficulty.

Dew is not formed on the surface of large bodies of deep water, for the cold particles of water sink, to be replaced by warmer particles from below, thus preventing a sufficient depression of temperature to allow of the deposit of dew. It is also not formed in the midst of sandy deserts, the atmosphere being too dry.

The *dew point* is the lowest temperature to which the air can be cooled down (at constant pressure) without depositing some of its vapour in the form of liquid water, or "the dew point is the temperature at which saturated water vapour would have the same pressure as that of vapour present in the air at the time," and can be calculated directly from Regnault's Tables if we know the quantity of vapour per cubic foot of air. Let it be supposed that the walls, ceiling, and floor of a room have been saturated with water, what will be the dew point? Here of course the water vapour present is saturated vapour, and therefore, what the dew point is will depend entirely on the temperature of the room; but dew will begin to be deposited as soon as the temperature falls below that which, as ascertained by Regnault, corresponds to the pressure of the water vapour present—*e.g.* if the temperature of the room be 40° C., then the vapour pressure corresponding to this is 54·906 mm. of mercury; and if the vapour pressure in the room be greater than this, then the excess will be deposited as dew; or conversely, if the vapour pressure present be 54·906, then the dew point is 40° C.: because if cooled the least bit below this, dew is deposited.

An early determination of the dew point may often be the means of foretelling a coming frost, and thus permit of steps being taken to prevent the destruction of tender plants. Other things being favourable, a dew point at or about 29° indicates frost. To protect the wheat crops in Manitoba from early frost it has been proposed to form clouds of smoke by setting fire to damp straw, the smoke so produced acting as a shield, preventing radiation.

Hail.—Hail consists of masses of hardened snow with a coating of ice. The hailstones vary in size and form.

Hoar-Frost.—A lower temperature is required for the formation of hoar-frost than for dew, which, however, is not frozen dew, but the moisture of the air deposited in a solid form. The crystals of hoar-frost are hexagonal prisms, with angles of 120°.

Formation of Clouds.—Clouds are formed by the condensation of vapour in a stratum of air at a low temperature, and at a considerable height—one to four miles—above the surface of the earth.

There are three varieties of clouds usually recognised by meteorologists as follow :—

1. CIRRUS, or the *Mare's Tail* of sailors, occupies the highest region of the atmosphere. It is higher than any point yet reached by balloons, and is probably composed of small particles of ice.

2. CUMULUS consists of rounded masses resting on straight bands, and having the appearance of hills or mountains. Sometimes they present the form of *balls of cotton* or *wool packs*, by which names they are known to sailors. They are most common in summer and during the day.

3. STRATUS consists of horizontal sheets, which form at sunset and disappear at sunrise. The strati are the lowest clouds. Besides these, which are the primary forms, there are several combinations of the above described—viz. *cirro-stratus*, *cumulo-stratus*, *cirro-cumulus*, and the *cumulo-cirro-stratus*.

The cirro-cumulus forms the well-known *mackerel sky*.
The cumulo-cirro-stratus is also known as the *rain-cloud*.
The cirrus, cirro-cumulus, and cirro-stratus are the higher ; the stratus, cumulus, and cumulo-stratus, the lower clouds.

(The above classification of clouds is that of Howard.)

Any cloud discharging rain has had the term *nimbus* applied to it.

Suspension of Clouds.—Clouds appear to be suspended in the air, because they are being continually formed. The heated air rises, the vapour is condensed, forms a cloud, and begins to fall ; but, coming in contact with warm air rising from the surface of the earth, is vapourised, again ascends, and is again condensed, to form a cloud. Clouds are constantly disappearing to be re-formed. From this we may explain the curious phenomenon of a cloud clinging to a high mountain, even with a strong wind blowing. The fact is, the cloud is as quickly formed as blown away.

The Estimation of Cloudiness.—The figures usually adopted are from 1 to 10. 1, Perfect freedom from cloud ; 10, the maximum of cloud ; any intermediate stage is marked 3, 4, 5, etc., as the case may require.

A *Mist* is a cloud near the ground.

A *Fog* is a cloud resting on the earth, and occurs when the surface of the ground is warmer than the air in contact with

it. The hot air rises to be condensed into fog. The fogs off Newfoundland are due to the excess of heat of the Gulf Stream above the cold moist air on its surface and over the banks. A fog may also be caused when hot moist air flows over a river with a temperature lower than the air; for then, the air being cooled as soon as it is saturated, the excess of vapour present is condensed. The London fogs are due to the artificially heated smoky air over the city, and the close proximity of the river Thames. It appears that these fogs are the result of a deposit of moisture on the particles of carbon or other matter in minute division suspended in the atmosphere. Aitken has shown that condensation cannot commence in free air unless dust-nuclei are present. Fogs seldom occur over deserts, and are not common in tropical countries, except round the tops of high mountains.

Rain.—As the clouds consist of particles of water, they are constantly raining; but between the clouds and the earth there is usually a non-saturated belt or region where these particles of water, when small, are evaporated before they reach the earth. When this belt becomes saturated, the particles coalesce, and rain is the result. We have already seen that when the moisture in the air is condensed as dew a considerable amount of heat is set free. The same occurs, but to a greater extent, during a fall of rain.

The specific heat of air is 0·2375, and a cubic foot of air weighs 560 grains; so that the condensation of one grain of aqueous vapour raises the temperature of one cubic foot of air $\frac{5760 \times \cdot 093 \times 9}{560 \times \cdot 2375 \times 5} = 7 \cdot 25^\circ$ F.

For one-tenth of an inch of rain it has been calculated that there is a rise of temperature in the lowest mile of the atmosphere equal to 3·3° C., sufficient to cause a considerable upward current. By the almost constant rains in the equatorial regions, an enormous amount of latent heat is set free, and the air thus rarefied helps to produce the trade winds. To this rarefaction we may trace the cause of the low barometer in the same regions. In higher latitudes, due to precipitation also, we find a low barometer and variable winds.

Causes that Influence the Rainfall.

1. *Latitude.*—The greatest rainfall is near the equator, diminishing towards the poles. But the number of rainy days at the equator and at latitude 60° are very nearly the same.
2. *Elevation above the Sea.*—Mountains increase the rainfall.
3. *Proximity to the Ocean.*—It is almost always raining on the west coast of Ireland and Britain. The Gulf Stream has much to do with this rainfall.
4. *Trees.*
5. *Winds.*
6. *Deserts.*—Almost entire absence of rain.

Rain may occur without clouds, due to clouds not in the zenith. It has also been suggested "that when rain falls from a cloudless sky, the vapour is condensed in a few large drops instead of a multitude of minute ones.

A *rainy day*, $\frac{1}{100}$ of an inch (Symons).

Mode of Estimating the Rainfall.

There are several forms of rain gauges. The simplest consists of a funnel, usually five or eight inches in diameter, opening into a receiver in which the rain is collected, and from which it may be drawn and measured. The funnel should have a truly horizontal rim, else the gauge will catch too much or too little, according to the direction and force of the wind.

Some observers maintain that the rain gauge should be placed *at least six inches* from the ground, to avoid splashing, and in the centre of a level, open plot; others that the best location for it is to bury it in the earth, making its top just even with the surface of the ground (Loomis). For some unexplained cause, the higher the gauge is placed above the surface of the earth the less rain it catches. The best time for measuring the rainfall is 9 A.M.

To calculate the quantity of rain intercepted by rain gauge.—Multiply the area of gauge by 252·458, divide product by 437·5; the result is the weight in ounces on one inch depth of rain over area of gauge.

252·458 = weight in grains of 1 cubic inch of water at 62° F.
437·5 = ,, ,, of 1 ounce avoirdupois.

$$w = \frac{a \times 252{\cdot}458}{437{\cdot}5}.$$

w = water in ounces. a = area of gauge, $D^2 \times 0{\cdot}7854$.

Suppose the diameters of the rain gauge and collecting glass be given,

to find the depth of the glass to contain 1 inch of water collected by the gauge. The diameter of gauge = 7 inches ; glass, 3 inches.

$$7^2 \times 0{\cdot}7854 = 38{\cdot}4846 \text{ area of gauge.}$$

$$\frac{38{\cdot}4846 \times 252{\cdot}458}{437{\cdot}5} = 22{\cdot}205 \text{ oz. of water.}$$

Then

$$\frac{22{\cdot}205}{3^2 \times 0{\cdot}45317} = 5{\cdot}44 \text{ depth of glass required.}$$

$0{\cdot}45317$ = a constant which may also be used to find the weight of an inch of water intercepted by the gauge, by multiplying the square of the diameter by it.

According to Mr. Symons, the mean annual rainfall is—at London and Edinburgh, 24 inches ; Liverpool and Manchester, 35 to 36 ; Dublin 30 ; Glasgow, 40 ; Dartmoor, 86 ; and on Ben Lomond, 91.

Atmospheric Electrical Phenomena.

The atmosphere is always more or less charged with positive electricity, especially during fine weather. During stormy or broken weather, negative electricity is as frequently met with as positive, and it is at such times that the indications of the presence of electricity are most marked.

Sources of Electricity.

1. Vegetation.
2. Evaporation from salt or saline water.
3. Condensation of vapour during storms.
4. Unequal distribution of heat.
5. Atmospheric friction.
6. Combustion at earth's surface.
7. Friction of the water vapour particles against the air particles, because when two different bodies are in contact they always give off electricity.

If moisture be in the form of true vapour, electricity is not generated.

Lightning Conductors or Rods.—Electricity travels along the best conductors, which are the metals. Lightning rods are, therefore, made of iron, pointed with copper or platinum, carefully insulated, and having one end buried in the ground. Care must be taken that the connection with the ground be continuous, that the diameter of the rod be about $\frac{9}{10}$ of an inch, and that in no part of its course must it come near any of the

metal pipes connected with the house. In the ground it may be connected with the iron gas and water pipes, or be attached to branching rods buried in the ground and surrounded with coke. Lightning conductors probably act in two ways: by affording a means by which the electricity may travel to the ground, and also by lessening the severity of the shock by allowing, by their pointed extremities, the gradual exchange of the opposite electricities of the clouds and earth. A sharp point connected with the earth modifies the sparks from the conductor of a machine.

CHAPTER VII.

VITAL STATISTICS.

THE subject may be defined as the application of the science of figures to all matters appertaining to the health of communities. The births, marriages, and deaths, together with the results of diseases of age and sex, and of those diseases incident on the occupation of individuals, all come under the investigation of the vital statistician, and for the sources of his information on these subjects he has recourse to the census returns, and to the published registered returns of births, marriages, and deaths.

The data on which this branch of the science is based are individual facts, or so-called "numerical units," all of the same nature, and which admit of their being compared with one another, added together, and classified. Each unit must have precise, definite, and constant characters, or else all classification is useless.

The first step is to arrange, by taking some distinctive feature, the isolated facts that are represented to us into groups or divisions. Having arrived at some sort of classification, we next compare each group with the total number of units taken together, and also with each other. For the sake of convenience we take 100, or some multiple of 100, as our numerical *constant*. Thus suppose the total number of deaths from all causes is 8212—of which 1378 are the result of zymotic disease, 3646 local, 224 violent, and so on, the percentage of deaths in each group will be found as follows :—

8212 : 100 : : 1378 : 16·8 percentage of zymotic deaths.
8212 : 100 : : 3646 : 44·4 ,, of local deaths.
8212 : 100 : : 224 : 2·7 ,, of violent deaths.

But if we want to know the relative percentages between

deaths and recoveries, we may proceed as follows. Take, for instance, 362 cases of pneumonia, divide into two groups, the deaths and the recoveries—19 of the former, and 343 of the latter,—and then proceed thus—

362 : 100 : : 19 : 5·248 per cent of deaths.
343 : 100 : : 19 : 5·54 per cent of recoveries.

The uses of vital statistics are, that they provide—

1. Information as to the health of the people.

2. Information as to the good or evil conditions affecting the people, and which enables us to take precautions against the spread of disease, etc.

3. Their application to Life Assurance, by which individual members may relieve the State of the burden of keeping their offspring, etc.

4. The fatality of different diseases at varying ages, and the protection of individuals at these critical periods.

5. The influence of professions, trades, locality, and age on the well-being of the community.

Census.

The basis of all vital statistics is population, and the first essential therefore is to obtain exact information as to the population, not in regard to numbers merely, but also in reference to age, sex, occupation, and condition.

This information can only be obtained by an exact enumeration ; this enumeration, which is known as the census, was first taken in this country in 1801, and has been taken at intervals of ten years since 1801. The method now employed in taking it is to leave at every dwelling-place within the district, upon a fixed date, a printed form with plain directions as to the manner in which it is to be filled up by the head of the household : the name, age, sex, occupation, condition as to infirmity, if any, and various other particulars concerning each inmate of the house on that particular night, have to be set forth. Extreme care is necessary in taking the census to ensure accuracy, and it is necessary that the officers who leave the papers and who subsequently collect them should be intelligent people capable of giving explanations where necessary. At every census it is probable that some error will always creep in, either intentionally on the part of those who misstate their ages or conceal the actual

number living in the house, or from carelessness and inattention, but this error is reduced to a minimum if careful precautions are taken, and an adequate and suitable staff is employed in distributing and collecting the papers. The census, however, is taken only every ten years, and in almost all communities considerable changes take place during this long interval. These changes are dependent upon the relative number of births and deaths, and upon the amount of immigration and emigration which has taken place during the period. In England and Scotland the growth of the population depends almost entirely upon the excess of births over deaths.

In the inter-censal period a simple method of estimation of the population is adopted. This method is based upon the assumption that the rate of change (increase or decrease) which was found to have taken place in a community during the ten years preceding the last census had continued since. For example, the census population of Edinburgh in 1881 was 228,346; in 1891 it was 261,225. The total increase therefore during the ten years was 32,879, and thus the increase each year would be 3287·9. This annual increase, if assumed to have continued, would make the population, *e.g.*, in 1895, 274,377, by the simple addition each year of 3287·9.

But this method makes no allowance for the increase of the added increment, which, in itself, increases at the same rate as the rest; and in order to include this element, instead of taking the actual figure indicating the population, the logarithm of that number is taken, which would raise the figure a little. Corrected on the census of 1901, the population of Edinburgh in 1895 was found to be 277,028.

In a large number of cases, besides Edinburgh, these estimates have been fairly correct, but the exceptions are numerous and important enough to prove conclusively that ten years is far too long an interval between the census. Thus, to take two towns of approximately equal population, viz. Newcastle and Salford, the error in the Registrar-General's estimate at the close of the previous decennial period (viz. 1891) in the one case was 11·7 per cent below the actual amount, whilst in the other case it was 25·5 per cent above, so that comparisons between the two towns would be misleading to the extent of 37 per cent. The error at that time in the estimate of the population of Liverpool reached 100,000. It is plain from

these examples that the comparative table of the death-rates of cities published week by week by the Registrar-General at that time was not dependable. To ensure reasonable accuracy the census should be taken at least every five years.

In estimating populations of districts, much valuable information can be got from other sources which enable the estimate to be checked—*e.g.* the number and size of inhabited houses, the increase or otherwise in subletting, the increase in the buildings in a growing suburb, or the diminution in the number of houses owing to extension of business premises in the central parts of cities, the numbers of children attending school, are all to be taken into consideration, and may, to a certain extent, be made use of in checking the correctness of the estimate.

A quinquennial census would go a long way towards remedying the uncertainties. Already in France, Germany, and other countries a quinquennial census is taken, and it is extremely desirable, in view of the important deductions drawn from statistical returns, that these returns should themselves rest upon a sound basis. It is sufficiently obvious that an error, either of over-estimating or under-estimating, must have a very serious influence upon sanitation. If, for example, owing to an over-estimation, the death-rate appears low, the public bodies will be loth to spend money in improvements for which there is apparently no need. If, on the other hand, owing to an under-estimation of the population, the death-rate appears higher than it actually is, the fact will be quoted as showing the uselessness of sanitary measures. There are many instances in which both of these evils have resulted from errors in estimates of populations.

If the rates of mortality and sickness are represented as less than they really are, the necessity for sanitary work is obscured, and conditions which may be eminently unsatisfactory are made to appear in a most favourable light; these circumstances are not calculated to stimulate sanitary work. On the other hand, if the population is under-estimated, sanitary works, however extensive, costly, and well directed, will appear to have no effect, or even to be associated with an increase of disease or death.

Registration of Births and Deaths.

It is obviously necessary that the registration of births and deaths should be accurately kept, since the facts derived from this registration are of supreme importance in determining, not only numerical changes in population, but the extent of mortality and the causes of it.

The law provides that births must be registered within forty-two days, either by the parent of the child, or by some person present at the birth, or in charge of the child.

Every death has to be registered within five days of its occurrence, either by the nearest relatives present at the death or in attendance during the illness.

The Registrar may register a death (*a*) on the statement of a qualified informant attending personally for the purpose, and producing a medical certificate as to the cause of death. When there has been no medical attendant, the Registrar must accept the qualified informant's statement as to the cause of death.

(*b*) On the certificate of the finding of a coroner's jury where an inquest has been held.

No record of still-born children is made in the register of births or deaths.

Uncertified Deaths.

A certain number of uncertified deaths—that is, deaths not certified by a medical practitioner, or after inquest—are registered. The Registrar accepts the statement of the informant as to the cause of the death, after making inquiries of the relatives of the deceased person.

Valuable uses are made of the information obtained by registration in preparing periodical returns as to the exact numbers of births and deaths; and, in the case of deaths, most important information is furnished as to the causes of death. It is this latter item of information which has proved a most important stimulus to sanitation. In certifying deaths it is desirable that simple, but precise, language should be employed, and that actual causes of death, and not symptoms, should be made use of—for example, it would be impossible to classify a death certified to be due to dropsy unless the cause of the dropsy were specified. When there is more than one

cause of death they should be written in the order of their appearance, and not in the presumed order of their importance. In certifying death after smallpox, it is essential that the condition of the deceased person as to vaccination should be stated.

Dr. Parkes remarked:—"An accurate diagnosis of the disease is essential, or statistical analysis can only produce error. If the numerical units are not precisely comparable, it is better not to use them. A great responsibility rests on those who send in inaccurate statistical tables of diseases; for it must be remembered that the statist does not attempt to determine if his units are correct—he simply accepts them; and it is only if the results he brings out are different from prior results that he begins to suspect inaccuracy."

The Registers of Births, Marriages, and Deaths contain the following facts:—

Births—(*a*) Date; (*b*) Sex; (*c*) Place of Birth; (*d*) Number (twins, etc.); (*e*) Legitimacy; (*f*) Residence of Parents.

Marriages—(*a*) Name; (*b*) Age; (*c*) Occupation; (*d*) Residence; (*e*) Condition of Husband and Wife.

Deaths—(*a*) Date; (*b*) Name; (*c*) Residence; (*d*) Age; (*e*) Sex; (*f*) Occupation; (*g*) Condition; (*h*) Cause of Death.

From these returns, the Health Officer is enabled to make the following important weekly returns as to the sanitary condition of his district:—

1. *Birth-rate.*
2. *Marriage-rate.*
3. *Total Death-rate.*
   - *A.* Death-rate at different ages.
     - (*a*) In Infancy—1. First week. 2. First year, etc.
     - (*b*) In Adults.
   - *B.* Death-rate from zymotic diseases.
   - *C.* Classified death-rate from other causes, violence, etc.
4. He can also infer the degree of healthiness or unhealthiness of his district.
   - *A.* Number of persons constantly sick, arranged according to age, sex, occupation, disease.
   - *B.* Average duration of illness.

In preparing these returns, certain precautions have to be taken. Thus, suppose a district divided into urban and rural

for sanitary purposes—both districts, however, combined in one Union, with the workhouse situated in the urban district; the death-rate and sick-rate will be increased in the urban and lessened in the rural; and unless allowance is made, a false return will be the result. A correction must, therefore, in all cases be made. Many of the deaths at sea-side places of resort are imported deaths, and should, if possible, be eliminated.

Registration of Sickness.

The registration of sickness has been advocated, and the advantages of some system which would ensure a return of recoveries as well as of fatal cases are very evident. An important step has been taken in regard to infectious disease under the provisions of the Infectious Disease Notification Act of 1899. This Act applies to practically the whole of Great Britain, notwithstanding that the adoption of the Act is voluntary. The principal provisions of the Act are as follows:—

Definition of Infectious Disease.

Infectious disease is defined by the Act to be smallpox, cholera, diphtheria, membranous croup, erysipelas, scarlatina or scarlet fever, and typhus, typhoid, enteric, relapsing, continued or puerperal fever.

The local authority of any district is also authorised, subject to the approval of the Local Government Board, to order that the Act shall apply in their district to any infectious disease other than the diseases specifically mentioned in the Act.

Notification of Disease.

Notice is required to be given to the Medical Officer of Health of the occurrence of infectious disease by

(*a*) The head of the family to which the patient belongs, and in his default,

(*b*) By the nearest relatives present in the building and in attendance on the patient, and in their default,

(*c*) By every person in charge of, or in attendance on, the patient, and in default of any such person,

(*d*) By the occupier of the building (as soon as he becomes

aware that the patient is suffering from an infectious disease).

(*e*) Every medical practitioner attending on or called in to visit the patient is required forthwith, on becoming aware that the patient is suffering from an infectious disease, to send a certificate to the Medical Officer of Health stating the name of the patient, the situation of the building, and the infectious disease from which, in the opinion of the practitioner, the patient is suffering.

Penalty.

Every person failing to give a notice or certificate shall be liable to a fine not exceeding 40s.

Forms of Certificate.

Forms of certificate will be supplied to any medical practitioner applying for the same to the Medical Officer of Health.

Payment of Medical Practitioners.

Every medical practitioner shall be paid for each certificate, if the case occurs in his private practice, the sum of 2s. 6d., and if the case occurs in his practice as medical officer of any public body or institution the sum of 1s.

Vessels, Tents, etc.

The provisions of the Act apply to every ship, boat, vessel, tent, van, shed, or similar structure used for human habitation, and any ship, vessel, or boat lying in any water not within the district of any local authority, shall be deemed within the district of such authority as may be fixed by the Local Government Board, and where the local authority is not so fixed, then of the local authority of the district which nearest adjoins the place where the vessel is lying.

The Act is not to apply to any vessel belonging to any foreign government, or to any building, ship, vessel, boat, tent, van, shed, or similar structure belonging to His Majesty the King or to any inmate thereof.

The Act has rendered invaluable service in checking the extension of infectious disease by enabling the Medical Officer of Health to take prompt measures for isolation of the patient, and to carry out such disinfection as may be necessary, and to prevent persons or things from infected houses disseminating disease. It has also enabled isolated cases to be linked together and traced to a common cause, such cause being promptly dealt with.

It has not been found in any way irksome or injurious, and the usefulness of this beneficial Act may be said to have received universal recognition.

Among the statistical uses which have followed from the Act, the average mortality in various epidemics of different forms of zymotic disease has been determined, and correct records of the prevalence of these diseases obtained. In practice, although the duty of notification rests upon the family or custodian of the patient, it is the medical practitioner who makes the notification in almost all instances.

Births.

The birth-rate is reckoned as a rate per 1000 of the total population living at all ages in the middle of the year. The birth-rate in different places in Great Britain fluctuates widely. In 1895 the lowest rate was in Sussex, viz. 24·3, the highest in Durham, viz. 35·8. The annual rate in some of the great towns in 1901 was as follows:—

Halifax	22·3	Dublin	27·4
Brighton	24·0	Leeds	29·9
Edinburgh	24·7	Glasgow	31·5
Derby	27·0	Liverpool	32·0

The rate also varies in different localities in the same towns, as the following table relating to Liverpool during the five years ending 1900 shows:—

Sefton Park District	22·8	Everton District	37·1
Wavertree ,,	28·0	Scotland ,,	39·7

The proportion of males to females also varies somewhat in different localities in this country; it averages 1004 males to every 1000 females born. The number of illegitimate births has decreased, and now approximates to about 1·3 per 1000.

Marriages.

The statistics of marriage are taken as an index of prosperity of a country, it being usually found that the marriage-rate increases in times of prosperity. The marriage-rate in Great Britain has shown some tendency to decline. In 1895 the rate was 15 per 1000 of the population; the mean age of men at marriage was 28·4, of women 26·2. Marriage is, as a rule, contracted earlier amongst the labouring classes than amongst the professional and independent classes.

Deaths and Death-Rates.

The most interesting, as well as the most important statistics are those dealing with mortality and its causes.

By "death-rate" is understood the ratio between the number of deaths and the population of any district during a given period. The period usually taken is one year, and the number of deaths is calculated per 1000 of the population during that period.

The death-rate is obtained by multiplying the number of deaths by 1000 and dividing the product by the total number of the population. Thus, the population of Liverpool in 1901 was 686,332, the total deaths 14,879 during the year:

$$\frac{14{,}879 \times 1000}{686{,}332} = 21{\cdot}6 \text{ per } 1000.$$

Mortality is sometimes expressed by the number of persons living, out of whom one dies annually. The preceding rate would represent one death in 46·3:—

$$\frac{1000}{21{\cdot}6} = 46{\cdot}3{\cdot}$$

The weekly rates of mortality, published by the Registrar-General, indicate that if the number of deaths occurring each week throughout the year were to be the same as that of the week in question, the annual death-rate would reach the figure indicated. Thus during a week in June the death-rate of Birmingham was 20 per 1000; this means that if the same number of persons who died during that week had died every week during the year, 20 out of every 1000 would have succumbed during the year. It does not mean that 20 out of every 1000 of the population succumbed during that week.

In calculating the so-called weekly death-rates, the population is divided by 52·17747 to reduce the annual population to a weekly population and so make the population and the deaths comparable.

In comparing the mortality statistics of one period with those of another, the following points have to be considered :—

1. Fluctuations of population.
2. Prosperous or adverse times.
3. Peace or war.
4. Favourable or unfavourable weather.
5. Social conditions and occupations.
6. Improved sanitary arrangements, new water supply, improved drainage, etc.
7. Epidemics.

Corrections for Age and Sex Distribution.

On comparing the death-rates of one locality with those of another, it is absolutely necessary, before any correct conclusions can be drawn from the comparison, to ascertain whether the populations of the two localities are comparable in point of age ; if they are not, then certain corrections must be made.

Quite apart from conditions of sanitation, mortality varies widely at different age-periods ; consequently the death-rate of a community is largely influenced by the relative numbers of people living at each age-period ; the effect of a high birth-rate in raising the crude death-rate is well seen by the table, which also indicates plainly enough how the crude returns are modified if there happens to be an unusual proportion at any one age-period. A hospital for foundlings, or a home for aged people, will have a very different influence upon mortality returns from a school containing an equal number of boys from 10 to 15 years of age.

It will be seen from the table that if, for example, we could conceive that the whole population of Liverpool consisted of persons between the ages of 20 and 30, the death-rate would have been 5·4 per 1000 ; if, on the other hand, we could conceive that it consisted entirely of people under 1 year of age, the death-rate would be about 214·4 per 1000, and if above 60 years, 73·2 per 1000. It is plain that any variation in the *proportions* living at the respective age-periods must affect the death-rate, and this with absolutely no change whatever in the condition of municipal sanitation.

THE FOLLOWING TABLE SHOWS THE ANNUAL RATE OF MORTALITY PER 1000 AT EACH OF TWELVE AGE-PERIODS DURING 1901 IN LIVERPOOL, AS WELL AS THE TOTAL NUMBER OF DEATHS. THE DIFFERENCES WHICH THE FIGURES SHOW ARE VERY STRIKING:—

1901.	Under 1 Year.	1 to 2	2 to 5	5 to 10	10 to 20	20 to 30	30 to 40	40 to 50	50 to 60	60 to 70	70 to 80	80 and upwards.	Total at all Ages.
Rate of Mortality per 1000 living at Ages indicated	214·4	82·5	19·7	6·3	3·3	5·4	10·7	18·6	31·9	55·7	99·3	186·1	21·6
Total Number of Deaths at each Age-period	4089	1363	950	466	454	720	1054	1339	1512	1557	1002	373	14,879

As the Registrar-General puts it:—"It must, however, be borne in mind that any comparison made between different towns in regard to the healthiness of their respective populations, if based simply on their general death-rates, as defined (see p. 603), is liable to lead to a more or less erroneous conclusion, unless it has been previously ascertained that the towns thus put into comparison show no material differences from each other in respect of the sex and age distribution of their populations; for it is self-evident that if the death-rates at each successive age-period be precisely alike in two towns, but in the population of one of them there be a much larger proportion either of very young or of very old persons than in the population of the other, the general death-rate will almost certainly be higher in the former than in the latter, inasmuch as the average mortality of the very young or very old is much higher than that of persons of intermediate ages; and so also will it be, if one town has a much larger proportion of males than the other, inasmuch as the male death-rate is almost invariably higher than the female death-rate."

The recorded and corrected death-rates per 1000 persons living in 15 great towns in 1901 are as follows:—

[TABLE

Towns, in the order of their Corrected Death-rates.	Standard Death-rate.	Factor for Correction for Sex and Age Distribution.	Recorded Death-rate, 1901.	Corrected Death-rate, 1901.	Comparative Mortality Figure, 1901.
Cols.	1.	2.	3.	4.	5.
England and Wales .	19·15	1·0000	16·90	16·90	1000
England and Wales, less the 15 towns .	19·47	0·9835	15·99	15·73	931
15 Towns . .	17·72	1·0806	18·59	20·09	1189
Brighton . . .	18·94	1·0110	16·53	16·71	989
Cardiff . . .	17·16	1·1159	15·76	17·59	1041
Wolverhampton .	18·30	1·0464	16·89	17·67	1046
Portsmouth . .	18·73	1·0224	17·85	18·25	1080
London . . .	17·97	1·0656	17·63	18·79	1112
Bradford . . .	16·81	1·1391	16·81	19·15	1133
Nottingham . .	17·81	1·0752	18·53	19·92	1179
Leeds . . .	17·28	1·1082	19·27	21·36	1264
Blackburn . .	17·05	1·1231	19·50	21·90	1296
Birmingham . .	17·33	1·1050	20·52	22·67	1341
Sheffield . . .	17·22	1·1120	20·41	22·70	1343
Newcastle-upon-Tyne	17·58	1·0892	21·89	23·84	1411
Salford . . .	17·03	1·1244	21·66	24·35	1441
Liverpool . .	17·44	1·0980	22·30	24·49	1449
Manchester . .	16·90	1·1331	22·10	25·04	1482

The *standard death-rate* signifies the rate at all ages calculated on the hypothesis that the rates at each of twelve age-periods in each town were the same as in England and Wales during the ten years 1881-90, the rate at all ages in England and Wales during that period having been 19·15 per 1000.

The *factor for correction* is obtained by dividing the standard death-rate in England and Wales by the standard death-rate in each town, and is the figure by which the recorded death-rate should be multiplied in order to correct for variations of sex and age distribution.

The *corrected death-rate* is the recorded death-rate multiplied by the factor for correction.

The *comparative mortality figure* represents the corrected death-rate in each town compared with the recorded death-rate at all ages in England and Wales in 1901, taken as 1000.

Infantile Mortality.

By the term "infantile mortality" is understood the proportion of deaths under twelve months of age to every 1000 births during the year. This method is adopted because the census returns relating to the first year of life are untrustworthy.

During 1901 the infant mortality in the great towns in England fluctuated between 127 per 1000 in Halifax, which was the lowest, up to 226 per 1000 in Burnley, which was the highest. There are wide ranges in different districts of the same town.

The high mortality amongst infants under twelve months of age, however good their surroundings, and however intelligently maternal care is exercised, arises from many causes: a certain proportion are premature, and cannot all survive; some are born with malformations and other defects which soon terminate their existence; others, the offspring of weakly parents, cannot long survive, and in spite of all care, there is a large proportion who will succumb to one or other of the many ailments to which infancy is susceptible. Making due allowance for these, it may be taken that an annual death-rate amongst infants of 100 per 1000 is unavoidable, and if this be granted, it follows that anything above this is preventable, although the necessary means to prevent it are so extremely difficult to apply that even in the best districts the loss of infant life is in excess of the standard. In the poorer districts it is plain to the most casual observer that necessary care and attention are not given to infants: nothing is more common than to see the infant handed over to the custody of children or irresponsible persons, whilst the responsible guardians are either at work or engaged in some other occupation. The children of the very poor are in this way exposed to neglect and inattention which is practically unavoidable, and which, together with improper food and scanty clothing, is reflected in the sacrifice of life.

A much closer differentiation, however, is possible in each district than is indicated by these broad distinctions. Thus, in the districts of highest mortality, whilst instances of families in which every child has been reared are numerous, there are examples, far too frequent, in which all, or nearly all, of the

children have perished in infancy, or before attaining the age of five years.

In the course of an inquiry into infantile mortality undertaken in Liverpool, 1082 families, in which the death of an infant had occurred, were taken consecutively, and certain particulars concerning them ascertained. The total number of children born in these families had been 4574, but out of that number 2229 had died, practically all in infancy, representing 487 deaths out of every 1000 born—a waste of life nearly five times as great as the standard alluded to. But the most remarkable series of excessive fatality occurred in twelve families in which the large total of 117 infants had been born, and no less than 98 had perished in infancy. These extreme examples, it must be remembered, are occurring in families in which, so far as municipal sanitation is concerned, there is very little to choose between them and many of the families who rear all, or nearly all, their children; nor can it be shown or inferred that there was any inherent weakness in the offspring, since those who have survived are of fair physique, not, as a class, suffering under any inherited condition likely to terminate their lives; but in the personal and domestic circumstances the contrasts are most marked.

A careful investigation has been made into the circumstances of upwards of 1000 consecutive deaths in districts where infantile mortality was excessive. In 21 per cent the families may be described as extremely and exceptionally dirty; in 18 per cent the mothers went out to work, leaving the infant in the custody of others,—frequently in the custody of another child, who could give it no proper attention. About 11 per cent of the total were living in dwellings unfit for human habitation. In upwards of 25 per cent—and these are the cases where the mortality appears to be highest—the parents are markedly intemperate. Upon this question it hardly needs to be pointed out that if the rearing of young infants requires care, and extreme care, the prospects of life of the infant are poor if the drunkenness of the mother results in its starvation and neglect.

As regards the nature of the illness to which death is most commonly ascribed, it must be borne in mind that the obscurity of symptoms of illness in infants often leaves a doubt as to which of two or more causes was the primary one. However

many deaths of infants under one year of age are ascribed to developmental diseases, premature birth, and atrophy, general experience justifies the assumption that the atrophy owes its origin in a very large proportion of cases to want of proper feeding. The group next in numerical importance is the zymotic group, the great majority being due to diarrhœa, the exciting cause being no doubt the same as that in the case of atrophy. Following upon this comes whooping-cough and measles. Under the heading "Diseases of the digestive system" many deaths of infants are recorded.

The following table gives the death-rates at twelve groups of ages of males and females in England and Wales per 1000 living at those ages in 1895 :—

Period—1895.

Ages.	Males.	Females.
0–1	176·0	144·0
0–5	62·1	52·0
5–	4·5	4·5
10–	2·5	2·7
15–	4·0	4·0
20– . . .	5·3	4·9
25–	7·2	6·7
35– . . .	12·2	10·3
45–	19·8	15·3
55–	36·3	29·8
65–	71·9	62·8
75–	149·9	136·1
85–	290·6	263·8
All ages	19·8	17·7

Influence of Trades and Occupations, etc., on Mortality.

With regard to the effect of professions and trades on the mortality of a country, definite data have been obtained.

The state most favourable to man is that in which he leads a regular life, with sufficient for his wants.

The researches of the late Professor Casper, contrary to the generally received opinion, show that the medical profession is perhaps more liable to early death than any other, and that

the clergy, in the list of mortality, occupy the opposite extreme.

Idleness and affluence are fruitful sources of disease.

All those professions which from their nature enjoin a more or less sedentary life are injurious to health, and therefore to longevity.

Lawyers confined to the desk, schoolmasters, clerks, literary men, and others, precluded from taking exercise in the open air or doomed to work to late hours of the night, are, as a class, not long-lived.

Shopmen, confined all day to close ill-ventilated shops, with little outdoor exercise, frequently fall victims to phthisis.

Stone-masons, lapidaries, knife-grinders, quarrymen, coal-miners, coal-heavers, pin-pointers, button-makers, pottery workers, flax hacklers, etc., are subject to diseases of the air-passages and lungs, phthisis, etc., due to the inhalation of solid particles of matter. *Grinder's rot* is a form of consumption more properly chronic bronchitis, well known among knife- and needle-grinders. In mines and other places where blasting operations are conducted the nature of the blasting material affects the character of the contained atmosphere; thus gun-powder adds carbonic acid, carbonic oxide, hydrogen sulphide, hydrogen, and suspended particles of potassium sulphate, potassium sulphide, sulphur, carbon, ammonium carbonate. Dynamite and gun-cotton add nitrous fumes, but no carbonic oxide or hydrogen sulphide. Roburite-chloro-dinitro benzol and ammonium nitrate produces but a small quantity of carbonic acid and no smoke. In all trades in which dust is the existing cause of disease free ventilation and the use of respirators have to a great extent lessened the mortality. Wet grinding, where possible, and the use of ventilating boxes to carry off the dust as formed, has done much to prolong life among those engaged in these dangerous trades.

White-lead manufacturers, plumbers, and painters are liable to paralysis and to lead poisoning, known as "painters' colic." *Prevention*—Grinding the lead in oil, cleanliness, and the use of lemonade mixed with dilute sulphuric acid.

Workers in mercury and gilders often suffer from a form of paralysis and salivation, called mercurialismus. *Prevention*—Free ventilation.

Chimney-sweeps are subject to cancer of the scrotum.

Phosphorus workers, to necrosis of the jaws. *Prevention*—The use of amorphous phosphorus in match-making, and free ventilation.

Arsenical workers and artificial-flower makers, to slow forms of arsenical poisoning. *Prevention*—Personal cleanliness, free ventilation.

Bakers, to skin eruptions, lichen, etc. *Prevention*—Cleanliness, free ventilation, and shorter hours of work.

Brassfounders, tin-plate workers, and coppersmiths, to a peculiar form of ague and colic. The urine of copper workers is said to be green from absorption of the metal, but their health does not appear to be much injured.

Paraffin Workers.—Dr. J. Bell has described a form of cancer, which he designates paraffin-epithelioma, among the workmen.

Quinine Manufactories.—The workers are often attacked by eczema of a very severe type, extending over the body.

Soda Factories.—The workers are attacked with erythematous eruptions. Their teeth become soft and translucent, and break off close to the gums (Layet).

Bichromate of Potash Manufactories.—The workmen suffer from troublesome sores, especially in the nose. *Prevention*—The use of snuff is said to prevent the injurious effects of this substance.

The Caisson Disease.—Men working in the large wooden or iron cases used in laying the foundations of bridges under water are subjected to extreme atmospheric pressure. When the men return to the surface, the diminished pressure produces severe pains in the joints and other troubles. In building the Forth Bridge, Belgian workmen accustomed to work in caissons had to be employed. The British workmen were unequal to the work.

Bleachers suffer from the effects of chlorine.

Straw-hat makers suffer from the sulphurous acid fumes used in bleaching the straw.

Shoemakers, from their sedentary habits, suffer in most cases from piles, and from the pressure of the last on the breast-bone.

The prevention or at least the lessening of the injurious effects of any of the above trades may be thus summed up:—Personal cleanliness, free ventilation, short

working hours, and healthy recreation in the open air.

Soldiers and sailors, if the former are not selected at too early an age, and the latter, when they escape the perils of their calling, are generally healthy and long-lived. The effect of recruiting the French army, in the time of Napoleon, with very young men was, that "they encumbered the roadsides and the hospitals." The late Anglo-Egyptian war has also shown the inefficiency of young soldiers. The earliest age at which the recruit should be admitted into the army is twenty; and, if admitted, should not be sent on active service till he attains twenty-three or twenty-five years of age.

On the whole, then, those professions and trades which admit of a due exercise of the healthy functions of the mind and body, together with a due amount of outdoor exercise, are conducive to long life; and the contrary, to early death.

Prostitution.—This is one of the most difficult questions which may engage the attention of the State. That prostitution is a terrible evil no one will deny; but few are agreed as to the measures to be adopted for its suppression. Besides the terrible diseases which promiscuous intercourse of the sexes engenders, the effect on the morals of the community is not less disastrous. In foreign countries the State has interfered, and prostitution is to a great extent regulated by State enactments. In 1845 a law was passed in Prussia to suppress all the brothels in Berlin and other large cities. Severe penalties were also imposed on those engaged in public prostitution. The result was that illegal prostitution rapidly spread, and public morals became so bad that, after a trial of six years, prostitution was again legalised.

The late Dr. Parkes remarks:—"The prevention of syphilis and gonorrhœa by periodical inspection of prostitutes, and removal of them to lock hospitals when diseased, is only carried out in this country in certain military and naval stations, where the effect has been to lessen primary syphilis by *nearly* one-half, and to abate its virulence. The effect of the Contagious Diseases Acts upon the women, in respect not only of curing them, *but of influencing them for good, and for reclaiming them*, has been very remarkable. In Germany, France, and Belgium, precautions against venereal diseases have been carried out among the entire population for many years, with the effect of

greatly lessening the amount and virulence of syphilis. As primary syphilis has a most pernicious effect upon the health of a large number of persons, it is most urgently to be hoped that the Legislature may before long deal thoroughly with this matter, and attempt to lessen syphilis, not merely in the army and navy, but among the population at large."

The following table gives some important results, and is taken from the Geneva Records :—

The Deaths in 10,000 Born were—

Period.	Under One.	Under Three.
Sixteenth century . . .	2592	4435
Seventeenth century . . .	2372	4100
Eighteenth century . . .	2012	3316
1814 to 1833	1385	3440

In the first period one-half died before they completed their ninth year; in the last, one-half survived their forty-fifth year.

Overcrowding.—The injurious effects of overcrowding are well known. Dr. Farr remarks, in the Fifth Annual Report of the Registrar-General, page 419, that the mortality is not only greater in town than in country districts, "but that the mortality of town districts has a certain relation to their density."

Density, however, must be regarded in conjunction with the poverty and intemperance often associated with it. If, as in the case of blocks of artisans' dwellings, sanitation is duly attended to, the ill effects usually associated with aggregation are absent.

Emigration.—This subject has become a matter of great importance, as the necessity of getting rid of our surplus population becomes more imperative. "From the beginning," remarks Herbert Spencer, "pressure of population has been the proximate cause of progress."

But may we not, in reducing our population by emigration, be parting with the better portion, leaving only the infirm and debilitated behind to still further deteriorate the race?

Dr. Acland remarks :—"The reality of our difficulty about population is told in a few words. England and Wales are increasing by about 200,000 annually. This number will, of course, increase by a small increment. Since A.D. 1810, the population, which was 10,000,000, has become 22,000,000;

and the same rate will, A.D. 1920, be over 45,000,000. The acres in England and Wales are about 37,325,000, including waste ground. There are now, therefore, nearly two acres per man ; in fifty years there will not be one. In Glasgow there are already 94 inhabitants to an acre, and in Liverpool 103."

Since Dr. Acland wrote, the population has increased to 25,968,286 in 1881, and is now over 30,000,000. Certain writers of late have recommended the limitation of families by the use of certain "checks." These opinions have not generally been accepted, but there is much to be said on both sides of the question.

Intemperance.—On this subject I shall quote from some valuable papers in the Annual Report of the State Board of Health of Massachusetts, kindly sent me by Dr. H. I. Bowditch :—

First.—Stimulants are used everywhere, and at times abused, both by savage and by civilised man. Consequently intoxication occurs all over the globe.

Second.—This love of stimulants is one of the strongest of human instincts.

Third.—Climate law governs it.

Fourth.—Owing to this cosmic law, intemperance is rare near the equator.

Fifth.—Intemperance causes little or no crime towards the equator. It is the almost constant cause of crime, either directly or indirectly, at the north, above 50°.

Sixth.—Intoxication is modified by race, as shown in the different tendencies to intoxication of different peoples.

Seventh.—Races are modified physically and morally by the kind of liquor they use, as proved by examination of the returns from Austria and Switzerland.

Eighth.—Beer, native light wines, and ardent spirits, should not be classed together, for they produce very different effects on the individual and upon the race.

Ninth.—Light German beer and ale can be used even freely, without any apparent injury to the individual, or without causing intoxication. So also may light grape wines, unfortified by an extra amount of alcohol.

Tenth.—Races may be educated to evil by bad laws, or by the introduction of bad habits.

Eleventh.—A race, when it emigrates, carries its habits with it, and for a time at least those habits may override all climate law.

The present intemperate condition of the English is due to several causes, among which may be noticed—bad legislation, and war. The prohibitive duties on light French wines forced the English to seek in

Portugal the strongly fortified port. This has been unfavourable to the moral status of England.

The writer of the paper also says :—

As a warning to our people, by our present unwise and high tariff on the mild wines of Europe, the people of this country are led to use the only drinks provided for them, viz. the coarser liquors. Are we not, in so doing, following exactly in the absurd way—I do not say wicked example—set by England two centuries ago? The civilisation of Monarchial Britain of the seventeenth century governs, in fact, Republican America of the nineteenth.

Total Abstinence.—On this subject opinions differ, and will continue to do so. The evidence of army surgeons, travellers, and insurance offices certainly go far to show that lessened rates of sickness and mortality follow the practice of total abstinence from intoxicants.

The "Rate of Mortality" and "Expectation of Life."

1. The number of deaths, say per thousand, within any given area, is known as the *rate of mortality.*

2. By the term "expectation of life," or rather "after lifetime," is meant the probability of the age any one person of a given population may attain according to the rate of mortality found to prevail within that area, regard being had to the age of the party at the time of fixing the expectation. At birth the *after lifetime* and the *lifetime* are the same.

The following table (in which the expectancy is somewhat lower than that of some others) is copied from Bourne's *Manual* "English Experience" No. 3 (Males).

[Table

Completed Age.	Years.	Completed Age.	Years.	Completed Age.	Years.	Completed Age.	Years.
0	39·91	32	31·42	56	15·86	80	4·93
5	49·71	33	30·74	57	15·26	81	4·66
10	47·05	34	30·07	58	14·68	82	4·41
11	46·31	35	29·40	59	14·10	83	4·17
12	45·54	36	28·73	60	13·53	84	3·95
13	44·76	37	28·06	61	12·96	85	3·73
14	43·97	38	27·39	62	12·41	86	3·53
15	43·18	39	26·72	63	11·87	87	3·34
16	42·40	40	26·06	64	11·34	88	3·16
17	41·64	41	25·39	65	10·82	89	3·00
18	40·90	42	24·73	66	10·33	90	2·84
19	40·17	43	24·07	67	9·82	91	2·69
20	39·48	44	23·41	68	9·36	92	2·55
21	38·80	45	22·76	69	8·90	93	2·41
22	38·13	46	22·11	70	8·45	94	2·29
23	37·46	47	21·46	71	8·03	95	2·17
24	36·79	48	20·82	72	7·62	96	2·06
25	36·12	49	20·17	73	7·22	97	1·95
26	35·44	50	19·54	74	6·85	98	1·85
27	34·77	51	18·90	75	6·49	99	1·76
28	34·10	52	18·28	76	6·15		
29	33·43	53	17·67	77	5·82		
30	32·76	54	17·06	78	5·51		
31	32·09	55	16·45	79	5·21		

A rough rule for arriving at the "expectation of life" is this. Between the ages of 20 and 45 use the fixed number 96. Deduct the present age of the person from this number, and half the remainder gives his expectancy. Between 20 and 30 the result is a trifle below the average; and over 40 is slightly above. For estimating the expectancy of those over 45 take 90 as the fixed number, instead of 96 as before.

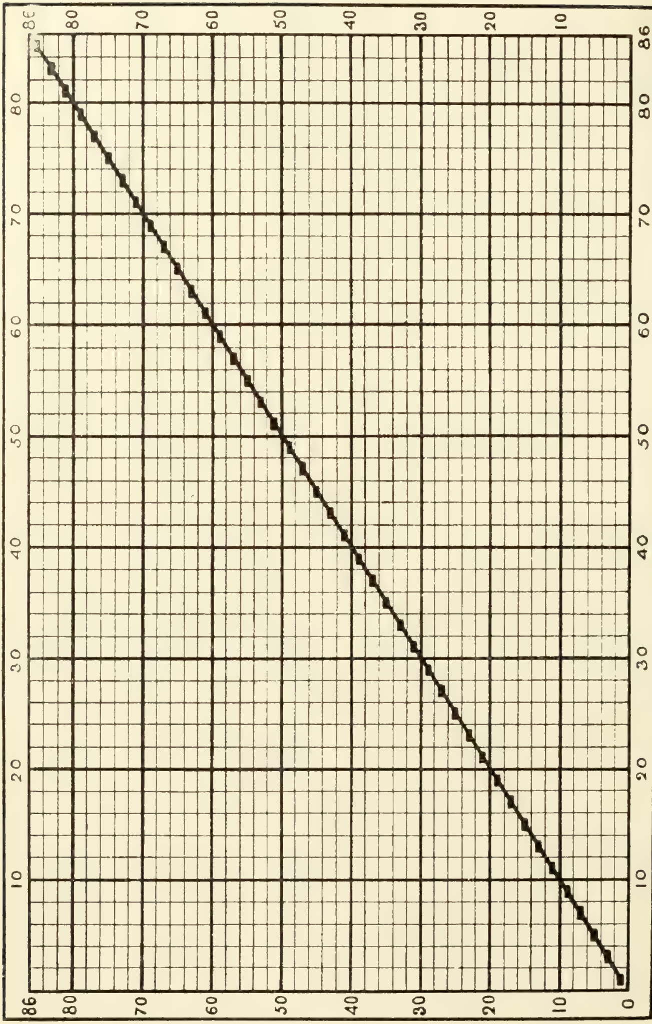
Taking the population generally, the expectation of lives in women is about three years more than in men. During the child-bearing period the expectation of women is somewhat less, but it rises, and is greater than that of men, after the fiftieth year.

The following is Willich's formula for calculating the expectancy of any age x:—

Expectancy of life $= \frac{2}{3}(80 - x)$.
Expectancy, 6 years of age $= \frac{2}{3}(80 - 6) = \frac{2}{3} \times 74 = 49·33$.

AGES.

NUMBERS OUT OF WHICH ONE WILL DIE IN EACH YEAR.



AGES.

Fig. 70.—Diagram showing De Moivre's hypothesis as to the law of mortality.

The "expectation of life" of any community is the true test of the health of the community.

The hypothesis of De Moivre, as to the law of mortality, was that, of 86 persons born, one died every year until all became extinct. According to this hypothesis, it is an even risk that on the birth of a child it will live 43 years, the chance of living or dying before that age being equal—43 being the half of 86 years. At age 20 there are 66 persons living; the half of 66 is 33, which, as the deaths are equal in each year, is the expectation of life at that age.

Mean Age at Death.—The mean or average age at death of any given population is the sum of the ages at death divided by the number of deaths.

Is the mean age at death a safe measure and standard of comparison? The mean age at death can be employed with safety as a true test or measure only in those cases in which the calculation purporting to embrace an entire class is included, or in which the calculations embrace only a section of an entire class; the class in question is retained in a state of perfect uniformity during the whole time comprised in the calculation. It is valueless as applied to a community varying under the usual conditions of life.

Mean Duration of Life.—The mean duration of life is found by adding the age to the expectation of life. It is, in other words, the expectation of life at birth. The mean lifetime in England, under the most favourable circumstances, is 49 years; under less favourable conditions, 41 years.

In the case of individuals longevity and a high mean duration of life throughout the community are not the same. The proportion of persons of advanced age is no indication of a long lifetime generally, but depends greatly on the proportion of children. Due to there being less children in France the percentage of persons over 60 is greater than in England, yet life is longer in the latter than the former country.

Table showing probable duration of male and female life in different countries at different ages.

Ages.	Sweden.		England.		Belgium.		Netherlands.		Bavaria.		General Mean.	
	Berg.		Farr.		Quetelet.		Baumhauer.		De Herman.			
	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.
Birth.	48	55	44	46	40	43	31	36	22	32	37	43
5 years.	54	59	54	56	53	54	51	54	53	53	53	55
10 ,,	50	55	51	52	49	51	49	51	50	49	50	52
15 ,,	45	50	47	48	46	47	44	47	46	45	46	47
20 ,,	41	46	43	44	42	43	40	43	41	41	41	43
25 ,,	37	42	39	40	38	40	37	39	38	37	38	40
30 ,,	33	37	35	36	34	36	33	34	34	33	34	35
35 ,,	29	33	31	32	30	32	29	31	30	29	30	31
40 ,,	25	29	27	29	26	28	25	27	26	26	26	28
45 ,,	22	25	23	25	22	25	22	24	22	22	22	24
50 ,,	18	21	20	21	18	21	18	20	18	18	18	20
55 ,,	15	17	16	17	15	17	15	16	15	15	15	16
60 ,,	12	13	13	14	12	13	12	12	12	11	12	13
65 ,,	9	10	10	11	10	10	9	9	9	9	9	10
70 ,,	7	7	8	8	7	7	7	7	7	7	7	7
75 ,,	5	5	6	6	5	6	5	5	5	5	5	5
80 ,,	3	4	4	4	4	4	3	3	3	4	3	4

Does a high Birth-rate involve a high Death-rate?—Not necessarily, if the high birth-rate be natural and the result of prosperity and easy circumstances. But if the high birth-rate be due to imprudent marriages or illegitimacy, the death-rate will be affected. Under the most favourable conditions infantile mortality reaches 100 per 1000, and a high proportion of infants in the population is bound to influence the general death-rate, and to raise it, under ordinary conditions. At the age of five the mortality, which had been gradually declining, is suddenly arrested; and it is at this age and during the succeeding decade that the probability of life is greatest. At puberty the maximum of viability is reached; after that period the mortality gradually increases, especially

among women, when the dangers of maternity are greatest. Between sixty and sixty-five the probability of life is lessened, and the mortality rapidly increases after this.

Marriage-rate.—The number of persons marrying per 1000 of the population living in the middle of the year.

Normal or Standard Death-rate.—In towns 17 per 1000 may be taken as a fair standard.

Zymotic Death-rate.—The total number of deaths occurring in a community during the year from small-pox, scarlatina, measles, diphtheria, whooping-cough, typhus, typhoid, relapsing fever, and diarrhœa, per 1000 of the population.

Approximately the mean death-rate of Great Britain in twenty-one years was 22·15 males and 20·58 females per 1000, the mean being 21·36.

Some of the leading causes which raise the death-rate of towns above that of rural districts are—

(*a*) Overcrowding in towns.

(*b*) Want of fresh air and sufficiency of pure water.

(*c*) Insufficient accommodation and drainage.

(*d*) Profligate and intemperate habits.

(*e*) Accidents.

(*f*) In large towns many die in the hospitals who ought to be accredited to the country. The death-rate of many watering-places is great only on account of the numbers who go for the benefit of health, but really to die.

The average mortality of one district of a town may be high, and yet the average of the whole be very low. Most towns afford a proof of the above statement.

A low death-rate may be due to the preponderance of adult and selected lives in a district.

The death-rate is not always a criterion of the healthiness or unhealthiness of a place; "a diminution in the rate of mortality will be found to co-exist sometimes with an augmentation of the rate of sickness. The very triumphs of advancing medical art are probably attended by an average prolongation of the helpless and infirm conditions of life." The highest ratio of sickness is sometimes found associated with a favourable rate of mortality (Neison).

The term *Morbidity* has lately been proposed to denote the amount of illness existing in a given community. It has been stated that the sick-rate of England and Wales is equal to the

loss of 2,000,000 weeks, or the work of 2,000,000 men for one week per annum.

The results of sanitary measures are most strikingly seen from a reduced death-rate from infectious diseases, phthisis, and other forms of tuberculosis.

Life Assurance.

Life assurance is based upon the observed ages at death of a definite number of people. Life tables (see EXPECTATION OF LIFE) are constructed from calculations based upon the census enumerations and the observed rates of mortality of say 1,000,000 persons at all ages. The figures show how many of a given number born live through each year of age, and what is the sum of the number of years they live. In the construction of Life tables all necessary corrections for age and sex distribution are made, and true death-rates for each year of life are given, *i.e.*, the proportion of deaths at every successive year of age to persons living at that age.

Life assurance is a contract by which a person, termed the *insurer*, in consideration of a sum of money proportioned to the risk, and technically called a *premium*, becomes bound to pay to the legal representatives of the *insured* at his death, or to the insured himself on his attaining a certain age, a sum of money previously agreed upon at the time of making the contract. Insurance is a consensual contract, but a written instrument on stamped paper is by statute requisite to its constitution.

There are three kinds of Life Insurance Companies—the Proprietary, the Mixed, and the Mutual.

In *Proprietary* Companies, the profits are divided only among the proprietors.

In *Mixed*, the insured participate in a portion of the profits, the rest being divided among the proprietors.

In *Mutual*, after paying expenses of management, the whole of the profits are divided among the insured.

Each of these modes of insurance has its advocates.

In an examination for life assurance, investigate the physical condition, and the family and personal history of the individual proposed. Tact will be required in ascertaining the use or abuse of alcoholic drinks, and the examiner will have to con-

sider the general appearance of the individual. Do the certified and apparent age correspond? Is premature baldness a family feature in the case, and does the history of longevity in the family contradict the apparent tendency to early degeneration? Do his weight and height correspond? These are some of the questions to be attended to, as regards the individual himself, but the examiner has also to investigate the nature of his surroundings and occupation. The unhealthiness of different trades and occupations is given on preceding pages, and these should be consulted. Answers to questions relating to the life history of the family should be regarded with care. An ophthalmoscopic examination of the eyes may often reveal unsuspected renal or nervous mischief.

Albuminuria may be due to a variety of causes, and may be divided into two classes, *Transient* and *Persistent*.

If the first is correctly diagnosed, Dr. Pavy does not consider the "risk" invalidated, but that in the second class the danger to life is invariably increased.

Albuminuria should, however, always be regarded as a "danger signal" in all applications for life assurance, and in persistent albuminuria, if the urine passed daily exceeds 60 ounces, the risk should be rejected. If the specific gravity is high with absence of sugar, albuminuria is less significant than with a low specific gravity, which is always suspicious of renal disease. A specific gravity of 1010 is the lowest consistent with health. An extra premium is demanded by excessive obesity, and 25 per cent extra is suggested by Dr. Sieveking. Gout also demands careful consideration, and the usual rating up of three to five years is not sufficient. In cases of heart diseases a guarded opinion should be given, but they are not now regarded as the barrier to life assurance they were some years ago. Dr. Sieveking would also add three years for a single hernia provided the patient wears a well-fitting truss. Tendency to phthisis will have to be considered.

CHAPTER VIII.

ZYMOTIC DISEASES AND HOSPITALS.

Epidemic diseases are those diseases which prevail occasionally with unusual severity, and at uncertain intervals, attacking large masses of the people, and lasting in most cases for some months, and obeying a certain law of periodicity,—the specific infectious matter multiplying *within* the body of the person affected.

Sydenham remarks :—"Atmospheric influences may so coincide with an epidemic as to forward its development, and to precipitate it, as it were, prematurely upon its victims." A distinction is drawn between indigenous and exotic infectious disease, in international agreements; especially rigorous steps being taken in Europe and America to exclude cholera, yellow fever, and plague. Epidemics of imported disease consequently have a more serious effect on international commerce than epidemics of indigenous disease. To the latter belong scarlet fever, typhus, small-pox, measles, etc. Indigenous diseases are usually present in a sporadic form—when, from some unknown cause, they suddenly become epidemic, and go through the several stages of *increase*, *maximum*, and *decline*. Sometimes the epidemic is very fatal, at other times mild; the characteristic eruptions at one time most marked, at another almost absent; the sequelæ may even differ in two epidemics of the same disease. The spread of epidemics is primarily due to contagion and infection. Two diseases may be epidemic at the same time,—typhus and relapsing fever,—but the one does not neutralise the other. The unrecognised existence of these diseases at the same time has given rise to the difference of treatment advocated by some observers. As long as susceptible persons are brought within the infected area, the epidemic

continues. The end of an epidemic, in the absence of sanitary measures, is held by some to result from the exhaustion in individuals of the special food of the germ of the prevailing disease. Imported diseases which become epidemic are generally absent for long periods—cholera epidemics occurred in 1832, 1849, 1854, and 1866.

The following table gives examples of diseases which are—or may be—

Endemic.—Goitre, Ague, Rheumatism, etc.
Endemic and Infectious.—Relapsing Fever, Typhoid.
Endemic, Epidemic, and Infectious.—Typhus, Small-pox, Scarlet Fever, etc.
Pandemic.—Diseases that have no special local habitat—*e.g.*, Influenza, Small-pox, Measles, etc.
These distinctions are purely arbitrary and empirical.
Contagious, but not otherwise Propagated.—Syphilis, Vaccinia, Hydrophobia, etc.

Any condition, whether acting primarily within the body, or as the result of physical influences acting without, that tends to lower the vital powers, is favourable to the inception and spread of an epidemic. Thus, the excessive heat of summer, if prolonged beyond the usual limits, tends to lower the resisting power of the system, and favours the growth and spread of diseases most obnoxious to the state of exhaustion thus brought about. Famine and drought are fertile sources of epidemics, and to these two causes, to a great extent, was due the fearful mortality during the period from 1833 to 1851. Religious and other social conditions, *e.g.* pilgrimages, are all more or less instrumental in the spread or prevention of epidemics; and diseases occurring among the lower animals, and in those vegetables most used for food, also add their influence to the list of causes of epidemics. The failure of the potato crop led to the Irish famine, with its terrible results.

A few of the diseases that have occurred as epidemics, and the means for their prevention, will now be given.

Cholera.—This disease has prevailed as an epidemic in England at various times, but notably during the years 1832, 1849, 1854, and 1866, when the mortality was very great; in 1892 it appeared again at Hamburg causing much loss of life. The disease seldom prevails as an epidemic during winter, though it has done so in certain Russian towns.

Origin and Cause.—Of the origin of cholera very little is known, but it has been shown by Pettenkofer and other observers that three factors—place, time, and individual—are necessary for its spread, these being usually spoken of as the local, temporal, and individual disposition. Investigations have shown that a bacillus called the comma bacillus has been found in the intestines, in the discharges and mucous membrane, and also in the water which had been drunk by cholera patients. It can be cultivated in almost any medium, best at a temperature of from 30° C. to 40° C., and measures about $\frac{1}{2}$ to $\frac{2}{3}$ the size of the tubercle bacillus. It is said to multiply outside the body, especially in water contaminated with organic matter. Although in the advance of cholera towards and through Europe, the places attacked were ranged along the great traffic lines, still it was noticeable that, whilst Paris and Marseilles were almost depopulated, Lyons escaped. But, further than this, one part of a town suffered more than another. Munich, Berg, and Flaidhausen were examples of this. In these towns it was almost universally noticed that the houses on the limestone gravel were those attacked, whilst those on the brick clay almost entirely escaped. This singular fact may be explained by the amount of ground air contained in loose, moist soils not saturated with water, and which is hourly drawn into the houses whenever they are warmer than the surrounding atmosphere. In clay soils there is but little of this ground air, and hence the comparative freedom from diseases which it affords. On the other hand, it has been argued that in water-clogged soils, or stiff clay, the surface water has a tendency to run off horizontally, but in porous soils the water sinks into the soil, carrying the germs of the disease into the wells. During the epidemic in London, in 1849, it was noticed that while the deaths on the low-lying parts of the city were 174 per 10,000, the deaths at 350 feet above the river were only 6 per 10,000. This difference might have been due to the better drainage of the higher parts of the town. Of the individual conditions favourable to the reception of the poison we know nothing, for all are attacked, irrespective of age, sex, or position in life, the strong claiming no advantage over the feeble. The disease may be communicated—

By pollution of drinking-water, milk, or other foods; by

insanitary conditions generally, notably filth, and especially excremental filth, which may contaminate air and soil, and water-supply.

The precautions, etc., are—

House-to-house visitation.

Early treatment of the first symptoms of diarrhœa. The best medicines are laudanum, aromatic sulphuric acid dilute, camphor, the compound aromatic chalk powder, etc.

A most careful disinfection of the stools or other dejections of cholera patients before allowing them to enter the sewers.

In small towns having only cesspools, the stools, etc., should be disinfected, and buried deep in the earth as far as possible from human habitations.

The treatment of cholera patients in isolation hospitals.

Careful disinfection of houses by the usual methods, and prevention of the access of ground air into them.

Small-pox.—This is the type of the zymotic class of diseases, and was first described by Rhazes, an Arabian physician. Natural or unmodified small-pox is now a rare disease, owing to the practice of vaccination. "There is no contagion so strong and sure as that of small-pox—none that operates at so great a distance." The disease may be spread by fomites, as by clothes sent to laundries or to pawnshops, by infected rags in "rag and bone shops," or by a dead body, etc. Small-pox is most fatal under five years, least between ten to fifteen, and again, more fatal after thirty. Dark-skinned races, especially negroes, suffer severely from small-pox. The period of incubation is about twelve days. The disease is ushered in with pains in the limbs and especially the *head* and *back*. Sudden chills and rigors are followed with an eruption on the third day of the fever.

The accompanying photographs illustrate the differences in the severity of the disease in the vaccinated and in the unvaccinated.

The precautions to be taken against the spread of small-pox are—

1. *Careful Vaccination.*—The proper view to take of vaccination appears to be this—that it does not always prevent small-pox, but modifies its virulence; and this is borne out by hospital statistics which show that the mortality in the vaccinated is 5 to 9 per cent, in the unvaccinated, 49 to 71 per cent. It has also been stated that syphilis is propagated by vaccination. We believe that the statements made on

this subject are overdrawn, and as animal lymph can be obtained from Governmental sources, this objection can scarcely now be entertained.

2. *Revaccination at Regular Intervals.*

3. *Immediate Removal by Special Means of Conveyance of those attacked to properly regulated Hospitals or Tents.*—This is the more important

FIG. 71.—Woman, age 30, vaccinated in infancy. Illness very modified; 12th day.

when small-pox attacks, as it generally does, those living in ill-ventilated and densely-populated courts and alleys.

In regard to revaccination, Mr. W. H. Power remarks—

"The protection against small-pox conferred by vaccination in infancy becomes diminished as age advances, and the protection against attack appears to diminish more rapidly than

the protection against death by the disease. Even before puberty a portion of the original protection is often lost; and this is particularly the case when the vaccination in infancy has been incomplete, having produced one vesicle instead of several, or small vesicles instead of large.

"Before vaccination was discovered, small-pox was, as for instance in London, a disease especially of children. But now, among vaccinated people, owing to the general protection of

FIG. 72.—Unvaccinated woman aged 23. 13th day of disease.

the children and the decline of this protection as life advances, such small-pox as prevails is principally seen in adolescents and adults.

"Thus it is of importance that the protection which vaccination affords to children should be renewed for them as they are growing up; and the law has provided gratuitous revaccination by public vaccinators for every one on reaching the age of ten years, and for all persons who within a like period have not been successfully revaccinated.

"In contrast with the immunity of revaccinated nurses in

FIG. 73.—Unvaccinated infant aged 3 months. 12th day of disease. Dead.

FIG. 74.—Small-pox modified in the mother by vaccination in infancy. The infant is vaccinated (see marks on arm), and escapes altogether.

attendance on small-pox cases may be noted the heavy incidence of the disease upon unrevaccinated public officials, and other persons brought, while in the performance of their duties, into contact with small-pox cases.

"The protection which is afforded by primary vaccination in infancy should be renewed as a matter of regular system by revaccination at least at the approach of puberty, and earlier in the case of children whose marks of primary vaccination are few, small, or indistinct."

The following table shows the condition as to vaccination, the age of the patient, and the character of the illness, in 840 consecutive cases of small-pox coming under the notice of the writer:—

[TABLE

TABLE SHOWING AGE, CONDITION AS TO VACCINATION, AND NATURE OF ILLNESS IN 840 CONSECUTIVE CASES OF SMALL-POX.

	Number and Character of Cicatrices.								Re-vaccinated.	Vaccination doubtful.	Not Vaccinated.
	Good.				Indifferent.						
Age.	1.	2.	3.	4 or more.	1.	2.	3.	4 or more.			
Under 1 year	...	...	1 mild	...	...	1 severe	...	...	...	...	4 severe
	...	...	...	...	...	...	...	...	...	...	6 fatal
1 year and under 10	2 mild	5 mild	7 mild	11 mild	7 mild	5 mild	10 mild	5 mild	...	...	...
	1 severe	2 severe	...	5 severe	6 severe	2 severe	5 severe	...	...	7 severe	45 severe
	...	...	...	...	...	...	...	...	.	...	25 fatal
10 years and under 20	6 mild	22 mild	39 mild	52 mild	5 mild	17 mild	21 mild	28 mild	*3 mild	3 mild	...
	9 severe	5 severe	6 severe	8 severe	17 severe	13 severe	16 severe	14 severe	...	9 severe	17 severe
	...	1 fatal	1 fatal	...	...	...	...	2 fatal	...	3 fatal	15 fatal
20 years and under 40	17 mild	21 mild	9 mild	4 mild	14 mild	22 mild	16 mild	10 mild	*2 mild	1 mild	...
	4 severe	21 severe	9 severe	...	27 severe	39 severe	16 severe	1 severe	...	5 severe	10 severe
	1 fatal	1 fatal	...	...	5 fatal	4 fatal	2 fatal	...	...	5 fatal	15 fatal
Over 40 years	2 mild	3 mild	...	...	5 mild	3 mild	1 mild	6 mild	...	1 mild	...
	5 severe	3 severe	...	...	10 severe	9 severe	1 severe	1 severe	...	2 severe	2 severe
	...	...	1 fatal	...	6 fatal	2 fatal	...	...	...	2 fatal	...

SUMMARY.

	Total.	Died.	Mortality.
Having one or more good scars . . .	284	5	1·7 per cent.
Vaccinated, having indifferent scars . . .	374	21	5·6 ..
Vaccination doubtful (no scar visible) . . .	38	10	26·3 ..
Not Vaccinated	139	61	43·9

* Said to have been revaccinated.

Scarlet Fever is the type of an infectious malady, and recent investigations have more than suggested that it is probably a disease of cows transmitted to the human subject. The disease in cows which is supposed to give rise to scarlet fever occurs as small vesicles and ulcers on the udder and teats. This is known as the "Hendon Disease." The streptococcus of scarlet fever was found in them, and a sub-culture of these given to calves produced the Hendon Disease. The poison appears to be less volatile than measles, but acts at a greater distance than typhus. It can be propagated in every possible way, even by letters sent by the post. Healthy persons may convey the poison without being themselves attacked. Schools frequently spread the disease. Scarlet fever is most prevalent in autumn, the mortality being highest in October and November. The death-rate is highest in young children—that is, under five years, adding about 0·5 per 1000 to the death-rate. Scarlet fever may disappear for three or four years and then reappear, due probably to the fact that the liability to the disease during the first year is almost *nil*, that it increases up to the fifth year and then declines. For a few years after an epidemic the community is thus to a great measure protected. More females are attacked, but more males die. The susceptibility to the disease diminishes after the fifth year. The period of incubation varies from a few minutes to five days, seldom exceeding six days (Murchison). The eruption, preceded by chills, rigors, sore throat, vomiting, and intense heat of the skin, appears on the second day of the fever.

"You will be asked," says the late Sir Thomas Watson, "at what period the danger of imparting the disease on the one hand, or of catching it on the other, is over; and I would recommend you to answer that you do not know. I am sure I do not, and therefore I always decline the responsibility of giving an oracular opinion on the matter." The more actively contagious period of the fever is uncertain. Some consider the period of desquamation, and therefore recommend inunction to prevent the scales flying about in the room. The predisposing causes are those which lower the vital powers—overcrowding, etc.

Prevention of Spread.

1. Isolation.
2. Exposure of clothes, etc., to dry heat or boiling water.

3. Fumigation of rooms with fumes of sulphur. Close all doors, windows, and chimneys, and burn from 1 to 2 lbs. of sulphur for every 1000 cubic feet of space. After some hours, open room and allow free ventilation.

4. Destruction of all infected articles.

5. Inunction of lard to prevent escape of epithelial scales, and the free use of soap and water.

MEASLES.—*One* of the *exanthemata*, and propagated in a like manner to scarlet fever, and as a rule recurring every third or fourth year. The mortality at all ages is about 0·4 per 1000, but under five years it amounts to 2·8 per 1000 living. The mortality is probably due to inter-concurrent capillary bronchitis, which is a most fatal disease among young children. Though comparatively a mild disease in this country, measles, when introduced to a new land, is most fatal. It nearly depopulated the South Sea Islands, as small-pox did the central and northern parts of North America. This severity is supposed to be due to the abundance in the blood of the fit pabulum for the germs of the disease, and which has not been previously partially exhausted by the germs of the other exanthemata. The period of incubation is from ten to fourteen days, and the eruption after a preliminary catarrhal attack appears on the fourth day of the disease.

Prevention.—Measures like those for scarlet fever.

PREVENTION OF SPREAD OF MEASLES.

As regards the influence of school closure upon the prevalence of measles it is interesting to note the experience of four years in Liverpool in regard to measles among children attending elementary schools. The subjoined table indicates the number of cases reported during one month *before* the holidays, and one month *after* the holidays, precisely the same machinery for notification being in force in each period. It would also appear that the longer the holidays the greater the effect in lessening the prevalence of the sickness.

Summer holidays.	During—	Cases of measles reported.	Winter holidays.	During—	Cases of measles reported.
1896.	One month before the holidays .	283	1896.	One month before the holidays .	143
	One month after the holidays .	35		One month after the holidays .	115
1897.	One month before the holidays .	991	1897.	One month before the holidays .	403
	One month after the holidays .	131		One month after the holidays .	171
1898.	One month before the holidays .	452	1898.	One month before the holidays .	205
	One month after the holidays .	137		One month after the holidays .	75
1899.	One month before the holidays .	1325	1899.	One month before the holidays .	501
	One month after the holidays .	182		One month after the holidays .	217
	Average of 4 years.				
	One month before the holidays .	763		One month before the holidays . . .	313
	One month after the holidays .	121		One month after the holidays . . .	144

The summer holidays extend to about five weeks; the winter holidays from a fortnight to three weeks.

Epidemic Influenza.—The grip. In 1729 there "broke out and raged all over Europe and perhaps the globe, a most universal epidemic catarrh," and in 1732-33, says Dr. Guy, quoting from Dr. Short, "the most sudden and universally epidemic catarrh that has been in this age, sparing neither ranks, sexes, or ages, old or young, weak or strong, and killing off many hectic and phthisical people." "In the space of twenty-five years," says Dr. Guy, "four well-marked epidemics of influenza occurred, this is in the years 1729, 1733, 1737, 1743." Within the last two or three years severe epidemics have also occurred. The disease does not appear to be connected with any insanitary condition, and the symptoms and

after effects have varied considerably among those attacked. Influenza spreads rapidly among all classes of a community, and this rapidity points to the air as the medium by which the contagion—said to be a micrococcus—is carried. The period of incubation is about two days. In some cases the respiratory tract was most affected, in others the alimentary tract suffered most, in still a third class of cases rheumatic pains in the joints and limbs were most severe. There was in all cases high temperature and much nervous depression.

Preventive Measures.—Isolation of those attacked, and aerial disinfectants.

Diphtheria.—The distribution of this disease is peculiar to itself, and the mortality from the disease does not appear to be regulated by the same causes that influence the general mortality, for density of population does not appear to favour it. It seems to have a preference for certain special districts, the great majority of which may be described as rural. The development of low vegetable organisms have, it would seem, more to do with the origin of diphtheria than the defective sewers and the higher sanitary developments of civilisation. Even privies and ashpits cannot be charged with its origin, for in towns where these abound the presence of diphtheria is by no means frequent. It is most frequently present in the rural districts of Ontario, Canada, though there cannot be a doubt but that pharyngitis with follicular secretion has often been mistaken for it, with many vaunted cures. It has been also suggested that it may be due to some disease among the lower animals with which rural are more frequently brought into intimate relation than urban communities. There appears also to be an individual susceptibility to the disease. Diphtheria chiefly attacks children between the ages of 2 and 10 years, and is most prevalent in the autumn or fall of the year. Schools afford a ready means of dissemination of the disease. Löffler has isolated a specific bacillus which may be found in the majority of cases of diphtheria, and which may be cultivated and inoculated upon animals, giving rise to diphtheritic conditions. Antitoxin is largely used for the curative treatment of diphtheria.

Preventive Measures.—Perfect isolation of those attacked, careful disinfection of all articles brought in contact with the patient, and the correction of all insanitary conditions.

Note.—The false membrane is said to be *croupous* when the epithelium of the mucous membrane is alone involved; *diphtheritic* when the deeper layers of the mucosa are affected.

Splenic Fever.—This disease is known as anthrax, charbon, malignant pustule, wool-sorters' disease, splenic fever, and splenic apoplexy. This disease, known under so many names, is found among cattle, horses, and sheep, but less commonly among swine and dogs, and is said to be caused by a bacillus, *the bacillus anthracis*. The disease can be communicated to man from the lower animals, and in both may occur under two forms—(1) local, (2) general, the former being chiefly manifested in man. In animals there is but little local lesion, the chief changes being found in the spleen, which becomes thoroughly disorganised, resembling a mass of blood-clot; hence the name splenic apoplexy. Hæmorrhages may occur in other organs, and serous inflammations with effusion may also be present. The blood is of a dark colour and is crowded with bacilli. In animals, but less so in man, the lymphatic glands are affected. The bacilli may be found in almost any part of the body of the animal or man attacked by the disease, but no spores are found in the blood. Anthrax occurs among persons working amongst hides, hair of cattle, etc., hence wool-sorters and tanners. Flies also probably carry the poison, especially if they alight on any abraded surface of the body, hence anthrax or malignant pustule may result from inoculation. The pustule does not contain pus, its presence being marked by a small hard pimple, surrounded by a bluish inflammatory zone, which rapidly increases, and a local gangrene and necrosis of the tissues ensue. Fresh vesicles or bullæ in the course of the disease may form round the primary one, and general blood poisoning may ensue. In the general form of the disease, of which malignant pustule is the local form, the respiratory tract is affected; wool-sorters' disease, on the gastro-intestinal tract, giving rise to diffuse inflammation, etc.

The bacillus anthracis occurs in the blood in the form of motionless straight rods joined end to end, with blunt slightly curved extremities. There are no spores in the blood, these being found only in the kidney. The bacilli vary from 5 to 20 μ in length, and 1·2 μ broad, and can be grown on gelatine, potatoes, agar-agar, in hay infusions, and in aqueous humour. They appear to require oxygen for their growth, but are killed

by an excess. Continued dryness destroys them, but they are not affected by freezing.

Glanders and Farcy.—Glanders is an inflammatory affection of the nasal mucous membrane, produced by the contagion of matter from a glandered horse. The bacillus is the *bacillus mallei*, and it has been proved to be the contagium of glanders, as that disease can be caused by inoculation, in horses, donkeys, etc., with it. In horses glanders is very contagious, and incurable. Farcy is an inflammatory affection of the skin, and of the absorbent system, produced by the contagion of matter from a horse having glanders or farcy.

Rabies.—Rabies is a disease common to many animals, especially those of the family *Canidæ*, of which the wolf and domestic dog are types. There is no aversion to water among dogs, and in this particular rabies in the dog differs from the disease when inoculated in man, and to which the name hydrophobia is properly given. All dogs should be muzzled, registered, and wear a collar with the owner's name and address, and all vagrant dogs killed. Suspected animals should also be killed or quarantined and muzzled. Pasteur, by means of inoculations of the virus of varying strengths has successfully treated many cases of the disease in man, reducing the death-rate from 15 per cent in the unprotected to 1·36 per cent in the protected.

Leprosy.—Elephantiasis Græcorum, lepra vera. The only European country where leprosy is still common is Norway, but it is also found in Sicily, Malta, parts of Portugal, the Levant, Crimea, in some parts of the East Indies, Africa, Central America, etc. Leprosy may be divided into two varieties, which, however, often exist together—the *nodular* or "tubercular," and *anæsthetic*. In some cases either variety may be preceded or accompanied with pigment spots; hence a third species, *lepra maculosa*. The disease may begin insidiously, accompanied with an outburst of bullæ, then violet or red patches varying in size, raised nodules, and infiltration of the deeper parts of the skin. The lymphatic glands enlarge. The nodules may shrink, leaving atrophied pigmented spots. Sometimes ulcers are formed. The course of leprosy is very slow, and there is very little pain. The general condition of the patient is little affected in spite of the steady continuance of the disease to a fatal conclusion. Death is generally due to

some intercurrent disease—pneumonia, pleurisy, etc.—which the general condition of the patient at last renders more than usually fatal. The cause of leprosy is unknown, the prognosis unfavourable, and treatment almost hopeless.

It does not appear that the infection is readily acquired, and the isolation of the sick is the most promising means of preventing the spread of the disease.

TYPHUS.—The result of a specific poison, probably of animal origin, apparently generated by overcrowding or ochlesis (ὄχλος, a crowd). Murchison maintained that the disease sometimes arose *de novo*, and gives three cases where typhus appeared, but no possible source of infection could be traced. In his cases the persons attacked were huddled together in a small room without any pretence at ventilation. The poison is not very volatile, and is almost entirely destroyed by free ventilation. Starvation, penury, want, and overcrowding are the predisposing and exciting causes of typhus.

Prevention.—Complete isolation of those attacked, free ventilation, and perfect cleanliness of everything used by the patient. The evolution of nitrous acid gas has been found of great use. The clothes of patients should be placed as soon as removed into boiling water, or into an oven and baked. Treat in well-ventilated wards or temporary wooden huts.

TYPHOID.—This is essentially a filth disease. Typhoid fever is propagated chiefly by the discharges from the bowels, and probably, as in typhus, the result of the admission of a poison of animal origin into the blood. The poison may be carried by water and by food. The carriage of the poison was traced to the milk used by those attacked, also to sewage-polluted oysters and mussels, and in one instance to contaminated fried fish. The common domestic fly may not improbably be a carrier of the poison from sewage to our food.

Prevention.—The isolation of the afflicted, and the most rigid attention to the proper disinfection of the stools with zinc chloride, ferrous sulphate, etc. "Never empty any evacuation into a closet, sewer, or cesspool; bury it several feet deep, and mix it well with earth" (PARKES). The clothes and bedding should be well fumigated and exposed to a temperature of at least 240° F. The purity of the drinking water and food, and the most efficient drainage, are absolutely necessary to prevent a future outbreak, and to arrest the existing one.

Relapsing Fever.—An infectious disease of uncertain origin, sometimes following periods of great scarcity, and certainly spread by overcrowding. It is endemic in Ireland and Silesia, sometimes becoming epidemic. Sir R. Christison spoke of its "spontaneous generation" from "penury, pent up in airless dwellings," as beyond doubt. Bacteria spirochætæ have been found in the blood of those attacked, disappearing with the remission of the symptoms and reappearing in the acute stage. No spores have been detected, and the spirillum has not been found in the tissues. Monkeys have been inoculated with the disease, and it has been transmitted from man to man.

Diagnosis.—After great depression in trade towards the end of the autumn quarter, the disease may set in with rigors, followed with sharp fever, vomiting, and epigastric tenderness, these symptoms subsiding with copious sweating about the fifth to the seventh day, but mostly recurring after the lapse of about a week, being then sometimes accompanied with jaundice and hæmorrhages, the symptoms again disappearing after copious sweating.

Yellow Fever.—A malignant epidemic fever, usually continued but sometimes assuming a paroxysmal type, characterised by yellowness of the skin, and accompanied in the severest cases with hæmorrhage from the stomach (black vomit), nose, and mouth. Yellow fever is essentially a disease of tropical climates, seldom extending beyond 40° north and 20° south latitude, and requiring a temperature of 72° F. at least to produce and spread it. It rarely occurs above 2500 feet from sea-level. Yellow fever appears to be due to the accumulation of fæcal matter round crowded and badly ventilated habitations, barracks, etc. The negro race appears to possess an absolute immunity from this fever, whereas the white races are most susceptible, especially new-comers into the yellow fever zone. The disease is not apparently due to malaria.

Prevention.—Good food and the other measures recommended for typhus.

The following diseases are spread by infection contained in the fæces of the sick :—Yellow fever, cholera, and typhoid fever, though, as in the last disease, persons convalescent may carry the disease. Parkes suggests that this may be the result of badly washed clothes.

Classification.

The classification of the Registrar-General of communicable disease is as follows.

Specific, Febrile, or Zymotic Diseases.

1. Miasmatic Diseases.—Eruptive fevers, influenza, pertussis, epidemic pneumonia.
2. Diarrhœal.—Enteric, simple continued, cholera, dysentery, diarrhœa, etc.

The seven principal diseases of the zymotic class belong to Orders 1 and 2.—(1) small-pox, (2) measles, (3) scarlet fever, (4) diphtheria, (5) whooping-cough, (6) diarrhœa, (7) fevers: typhus, enteric, and simple continued (febricula).

3. Malarial diseases.
4. Zoögenous diseases include vaccinia, rabies, glanders, splenic fever.
5. Venereal diseases.
6. Septic diseases include erysipelas, pyæmia, septicæmia (puerperal and non-puerperal).

The Means by which Zymotic Diseases are Spread.

1. Difficulty of isolating the sick.
2. The sale of infected clothing, etc., in rag shops.
3. The letting of infected houses and apartments, schools.
4. Incautious conveyance of the sick in cabs, etc.
5. Convalescents, laundresses, tailors, etc.
6. Foul water, bad drains, etc.

Influences under which Zymotic Diseases arise.

The causes which appear to influence the rise and spread of zymotic diseases may be tabulated thus:—

(1) Those which belong more particularly to Locality.
(2) Those which depend upon Population.

I.—THOSE OF LOCALITY.

1. Locality.—This can scarcely be considered in old-established countries, and is more important in countries where new communities are being formed; for then it may be stated that the higher the situation above sea-level the greater freedom from zymotic diseases.
2. Drainage.—Bad condition or absence of w.c.
3. Age, Construction, and Condition of Houses and Streets.—The

effect of these causes is notably seen in all old towns—such as Edinburgh, Dublin, London, etc.

In the old town of Edinburgh fever was formerly almost endemic, and the same appeared to be the case in Dublin. The narrow streets in the old town of Edinburgh, combined with the age and filthy condition of the houses, the density and poverty of the population, all tended to localise fever in these parts.

4. Season and Climate.—These have been mentioned before.

II.—THOSE OF POPULATION.

1. Density of population.—The unhealthiness and increased death-rate due to this cause have been discussed elsewhere.

2. Pauperism.

3. Cleanliness.—This is almost absent in poor districts, dirt prevailing everywhere.

4. Improper accommodation for the sick.

Tuberculosis.

The following resolutions were passed at the general meeting of the British Congress on Tuberculosis, held in London in 1901:—

That tuberculous sputum is the main agent for the conveyance of the virus of tuberculosis from man to man, and that indiscriminate spitting should therefore be suppressed.

That it is the opinion of this Congress that all public hospitals and dispensaries should present every patient suffering from phthisis with a leaflet containing instructions with regard to the prevention of consumption, and should supply and insist on the proper use of a pocket spittoon.

That the voluntary notification of cases of phthisis attended with tuberculous expectoration, and the increased preventive action which it has rendered practicable, has been attended by a promising measure of success, and that the extension of notification should be encouraged in all districts in which efficient sanitary administration renders it possible to adopt the consequential measures.

That the provision of sanatoria is an indispensable part of the measures necessary for the diminution of tuberculosis.

That in the opinion of this Congress and in the light of the work that has been presented at its sittings, medical officers of health should continue to use all the powers at their disposal, and relax no effort to prevent the spread of tuberculosis by milk and meat.

That the educational work of the great national societies for the prevention of tuberculosis is deserving of every encouragement and support. It is through their agency that a rational public opinion may be formed, the duties of public health officers made easier of performance, and such local and State legislation as may be requisite called into existence.

That this Congress is of opinion that a permanent international committee should be appointed—(*a*) to collect evidence and report on the measures that have been adopted for the prevention of tuberculosis in different countries; (*b*) to publish a popular statement of these measures; (*c*) to keep and publish periodically a record of scientific research in relation to tuberculosis; (*d*) to consider and recommend measures of prevention. This Congress is further of opinion that all international and great national societies whose object is the prevention of tuberculosis should be invited to co-operate.

That in the opinion of this Congress, overcrowding, defective ventilation, damp and general insanitary conditions in the houses of the working classes diminish the chance of curing consumption and aid in predisposing to and spreading the disease.

That, while recognising the great importance of sanatoria in combating tuberculosis in all countries, the attention of Government should be directed to informing charitable and philanthropic individuals and societies of the necessity for anti-tubercular dispensaries as the best means of checking tubercular disease among the industrial and indigent classes.

HOSPITALS.

Accommodation for the Sick.—This is provided for under Section 131 of the Public Health Act, 1875, by which the L.A. may build or lease a building for the purpose, or they may farm their sick in any hospital by paying for the reception of the same. Two or more L.A. may combine to provide a common hospital.

Hospitals should be built, if possible, on dry porous soil, well drained, with the wards facing south-east and north-west, and on the pavilion plan now so much advocated. This consists of a collection of small hospitals connected by corridors, the distance between the pavilions being about twice the height of the pavilions to allow of free circulation of air around each building. Mr. Marshall has suggested circular wards for the

following reasons:—Better supervision, warming and ventilation are easier, cleanliness is better secured, and there is greater economy in management. There is, however, great waste of space in the centre of the ward. Hospitals with circular wards have been built at Greenwich, Antwerp, and elsewhere. All the sanitary arrangements should be as perfect as possible, the water-closets being placed as far as practicable outside the wards. The windows—one to every two beds—should be on each side of the ward to allow of cross ventilation, and should extend from 2 to 3 feet above the floor, to between 6 to 12 inches from the ceiling of the ward. The windows should be made to open at the top sash, or be provided with ventilators in one or more of the panes of glass. The corners of the ward should be rounded to prevent the collection of dust, etc. The unit of an hospital is the ward, and this should not contain more than thirty-two beds, the number fixed by Miss Nightingale as capable of being watched over by one head nurse. The temperature of the ward should be about 60° F., and this is best maintained by the use of Musgrave's grates and hot-water pipes. The products of combustion of gas jets should be removed by extraction flues over each jet, but electric lighting is far better. The floors are best made of hard wood polished. Each patient should be allowed at least 1600 cubic feet of space, and a superficial area of 144 square feet for each bed. For infectious diseases these numbers should be increased. The establishment of cottage hospitals in rural districts has been found of great advantage, one bed being provided for each 1000 persons in the district. The size of infectious hospitals will depend upon the population of the town, one bed being provided for every 1000 or 2000 of the population.

Hospitals for Infectious Diseases.

Extracts from Memorandum issued by the English Local Government Board on the Provision of Isolation Hospital Accommodation by Local Authorities.

The provision of hospital accommodation for cases of infectious diseases is to be regarded primarily as a measure of sanitary defence for the protection of the public against the spread of these diseases. It is true that such accommodation incidentally serves other useful purposes. Thus, it is frequently of value

for the relief of individuals suffering from infectious disease, whose sufferings may be alleviated and their recovery promoted by affording them better accommodation and attendance than they are able to obtain at their own homes. Or it may be the means of avoiding serious inconvenience and pecuniary loss, as when infectious disease breaks out in a school, a lodging-house, or a place of business. But, nevertheless, the most important function which such a hospital serves is that of the isolation of the first cases of infectious disease with a view to preventing its further spread in the household or locality invaded.

In order that a hospital may fulfil this function it is essential that it should be in readiness beforehand. Experience has shown that on the invasion of an epidemic, a hospital, even of a temporary kind, can seldom be provided and got ready for use until the time when it would have been of most service is past. The accommodation, moreover, which is required when an epidemic has become established is on a larger scale than would have sufficed for the isolation of the first cases; and hospitals hurriedly erected during the stress of an epidemic are never satisfactory in construction or suited to the permanent needs of the district.

It is undesirable that admission should be subject to restrictive charges and conditions which may tend to prevent the use of the hospital by the poorer portion of the community,—that is to say, by those who have the least facilities for isolation and treatment at their own homes. In some districts, however, *e.g.* at health resorts, it may be advisable to provide special accommodation of a superior kind, such as private wards, for persons willing to pay for it.

Area to be Served by a Hospital.—The extent of area for which an isolation hospital may serve will depend in some degree upon considerations of local topography. If the area be too large the usefulness of the hospital will be diminished, owing to the difficulties attending the conveyance of patients over long distances. But, on the other hand, the unnecessary multiplication of small hospitals is to be avoided on grounds both of economy and of efficiency. As compared with that of several smaller hospitals, the establishment of a single hospital containing an equal number of beds saves the cost of duplicating various buildings, appliances, and officers; it facilitates the classification of patients according to the diseases from which

they are suffering; and it enables a more efficient staff to be maintained, since the hospital is less likely to remain empty for considerable periods. Hence, where districts are not very large or populous, combination for the purpose of providing hospital accommodation is often of advantage. In the less densely populated parts of the country, a market town with the surrounding rural district, or the several sanitary districts comprised in one poor-law union, may form a convenient area for the purpose of combined hospital provision. A hospital intended solely for small-pox may serve a larger area than a hospital for other infectious diseases. The modes by which local authorities may combine for the provision of hospitals are set forth in an office memorandum on "Isolation Hospitals," which may be obtained on application, for the guidance of local authorities desirous of such combination or of establishing hospitals under the sanction of the Local Government Board.

Size of Hospital in Proportion to Population.—The amount of permanent isolation hospital accommodation which should be provided in proportion to the population will depend upon various considerations, among the most important of which are the character of the district, whether urban or rural; the rate of increase of population; the housing and the habits of the people; and the amount of intercourse with other places from which infectious disease may be introduced. As a rough estimate, one bed for every thousand inhabitants is sometimes adopted, but in view of the diverse circumstances of different districts this cannot be regarded as a definite standard. Moreover, the sufficiency of the hospital accommodation will depend not merely upon the aggregate number of beds, but also upon the way in which they are arranged in wards. In a single block with wards connected together only one disease can safely be treated at a time; and thus, at a hospital containing only one such block, occasions may arise when, owing to the hospital being partly occupied by one disease, a case of a second disease requiring isolation cannot safely be taken in, although there may be a number of beds empty at the time.

It is common to find that the demand for hospital accommodation, when people have come to appreciate the benefits of its use, increases far beyond what was at first anticipated; and for this reason, as well as to allow for growth of the population and for the possible need for temporary extensions during

epidemics, it is well at the outset to provide for the contingency of future enlargement.

Site.—In selecting a site for an isolation hospital the following considerations should be had in view:—It should be convenient of access, and, as far as practicable, central for the population and area which it is to serve; but of course not in a very populous neighbourhood. (In the case of hospitals in which small-pox is intended to be received the choice of site must be specially governed by considerations as to the number of inhabitants in the neighbourhood, which will be referred to later on.) It will be of much convenience if sewers and a public water service are available; but, if not, a sufficient supply of wholesome water must be provided, and arrangements will have to be made for the treatment of the sewage by application to land, due care being taken to avoid pollution of any well or spring or of any river. The site should be in a healthy and open situation with a dry subsoil, and should be preferably of a compact and regular shape, and not too steep. Its area will depend upon the size of the hospital, and, except in the case of a very small hospital, should rarely be less than two acres; indeed, it is well to obtain a larger site than may at first be required in order to afford space for subsequent extension if necessary. More land, too, will be needed if the sewage has to be disposed of on the site. *The site, or so much of it as is to form the grounds of the hospital, should be enclosed by a wall or close fence at least* 6 *feet* 6 *inches in height, and every building which is to contain infected persons or things should be at least* 40 *feet distant from the boundary.*[1]

Hospital Buildings.—These should be of three classes, viz.—1st, Ward-blocks for the reception of the sick; 2nd, Administration-block for the housing of the staff and stores; and 3rd, Out-offices, as laundry and mortuary. In hospitals for permanent use these buildings should be of brick or stone. Temporary buildings—as for instance, buildings constructed of wood or corrugated iron—are ill suited for permanent use as hospitals, for the reason that it is difficult to maintain them at a proper temperature during extremes of hot and cold weather; more-

[1] If desired, an open unclimbable railing may be substituted for a wall or close fence for so much of the boundary as is within supervision and control from the administration block or porter's lodge, as shown on page 653, block plan A; but in that case a second line of unclimbable fence should be constructed within the first, as indicated on the plan.

over they are less durable than brick or stone buildings, requiring more frequent repairs in order to keep them in a

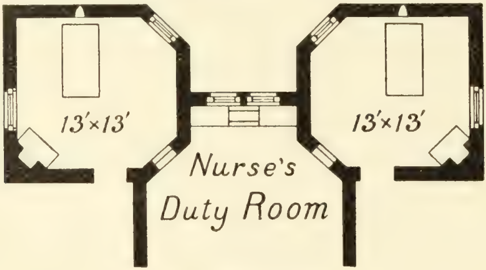


FIG. 75.—ALTERNATIVE PLAN.
Showing two separation wards.

properly weather-proof condition, and they are liable to be destroyed by fire and storm. *It is not the practice of the Local Government Board in ordinary cases to sanction loans for iron*

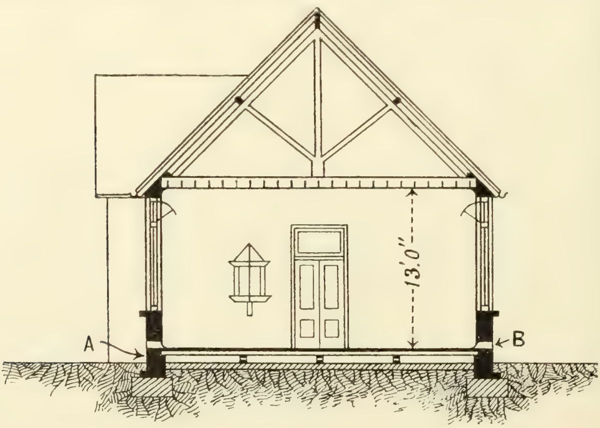


FIG. 76.
A, damp-course; B, air-grating behind each bed.

hospitals or for hospital buildings of temporary character.

Existing buildings originally designed for a different purpose, such as dwelling-houses, even when of large size, are rarely

found to be well adapted for the reception of patients, especially for the accommodation at one time of patients suffering from different infectious diseases. An existing house, however, may sometimes serve as the administration-block, if it has sufficient land attached on which to erect ward-blocks.

The *administration-block*, which should be kept free from patients and infected articles, should be so placed as to control the entrance to the hospital grounds, unless a porter's lodge is intended to be erected. It should contain quarters for the matron or caretaker, and a sufficient number of bedrooms for the nurses and servants who will be required to work the

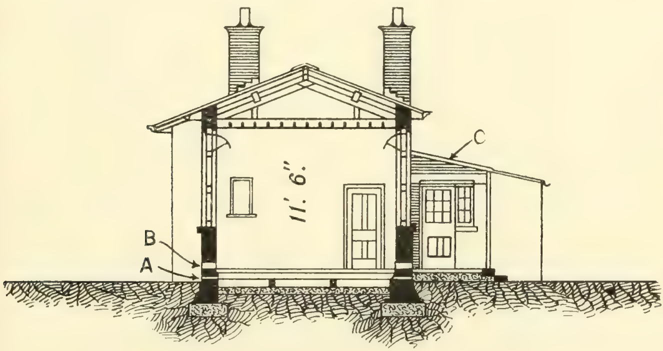


Fig. 77.—Section.
A, damp-course; B, air-grating; C, glazed roof.

hospital when in full operation; also a nurses' sitting-room; a kitchen (preferably in a one-storey projection with top ventilation), store-rooms, dispensary, etc. In hospitals of considerable size quarters for a resident medical officer will also be necessary. It is well to provide in the administration-block accommodation on a scale somewhat in excess of what may be at first required, in order that it may be available for future extensions of the hospital, temporary or permanent; but in any case the block should be so planned that it can be easily enlarged in the future if necessary.

The *ward-blocks* should be one-storey buildings, unless where in exceptional cases or at large hospitals exigencies of space may render it necessary to construct blocks of two storeys; in

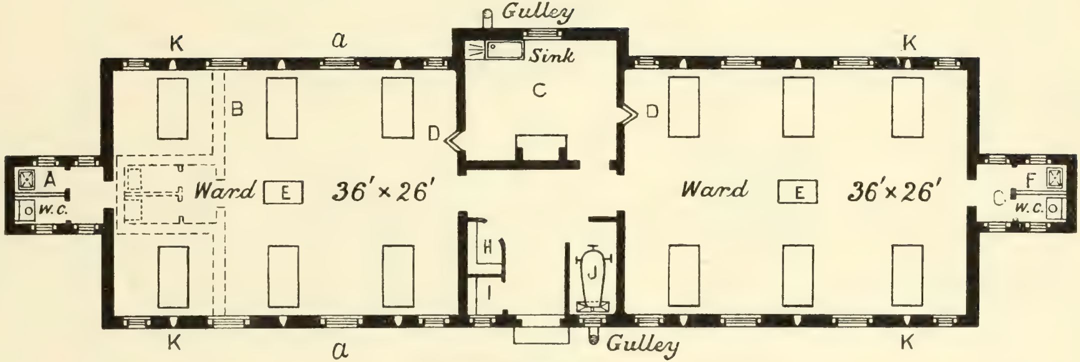
such case each storey should have a separate entrance from the open air. The annexed plans illustrate two different types of ward-block suitable for small or moderate sized hospitals. The type illustrated in plan C is the most advantageous as regards both cost of construction and convenience of administration, where a number of patients of both sexes suffering from the same disease have to be treated at one time. The number of beds in each ward will vary with the requirements of the district, and it is sometimes found desirable to make one ward rather larger than the other, as indicated on the plan, in order that young children of both sexes may be treated in the women's ward.

Plan B shows a ward-block with small wards separately entered from the open air under a verandah. Accommodation of this kind is useful not only for cases of a second disease, but also under a variety of circumstances, as for the keeping under observation of a case of doubtful nature; for the segregation of a complicated, noisy, or offensive case; or as private wards for paying patients, etc.

For very large hospitals other types of ward may be found of advantage.

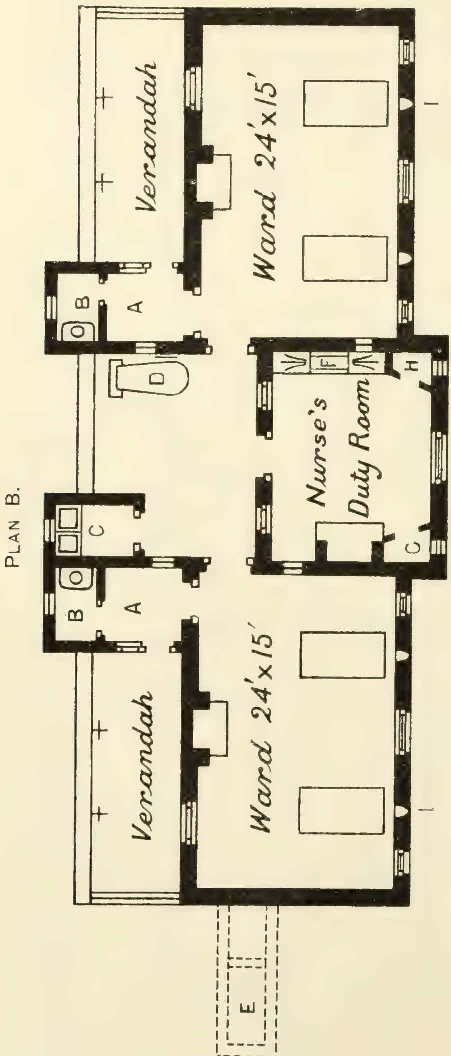
In the ward-blocks each bed must have at least 12 *linear feet of wall space*, 144 *square feet of floor space, and* 2000 *cubic feet of air space.* In calculating the latter any height of wards above 13 feet should not be taken into account. The walls should be of adequate thickness; and the inner face of the walls as well as the floors and woodwork should be constructed with smooth impervious surfaces and rounded angles, so as to facilitate cleanliness and to avoid spaces which may harbour dust and dirt. Ventilation should be by windows on opposite sides of the ward; the windows should be double-hung sashes with fanlight above, and the fanlight should be made to fall inwards, hopper-fashion, with side cheeks to prevent down draughts. The area of the windows should be sufficient, but not excessive; one square foot of window to every 70 cubic feet of ward space is a suitable proportion. The best aspect for the ward-blocks is usually with the windows facing respectively south-east and north-west. The wards should have adequate means of warming, which may with advantage be so contrived as to furnish a supply of warm fresh air. An ample supply of hot water for baths should be provided, and bathrooms should be capable of being warmed. The closets and slop-sinks should

PLAN C.



Scale—16 feet to 1 inch.

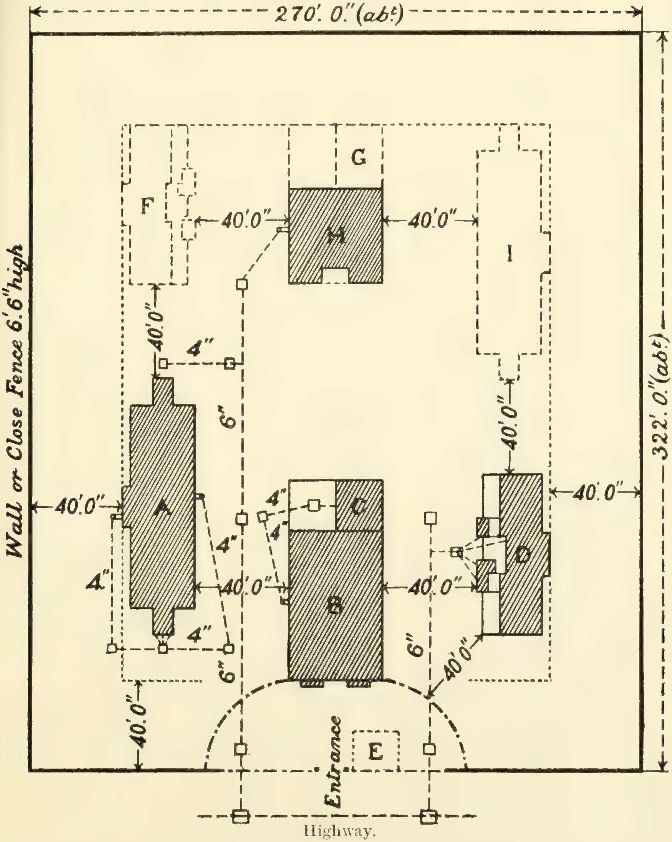
FIG. 78.—A, slop sink; B, alternative position of end wall, etc., if ward of smaller size; C, nurse's duty room; D, fixed inspection windows; E, store; F, dwarf partition, 6′ 6″ high and 6″ off the floor; G, this partition should be taken up to ceiling, so as to shut off W.C. and sink from the lobby when the doors are shut; H, linen; I, store; J, bath; K, air-grating at floor level.



Scale—16 feet to 1 inch.

FIG. 79.—A, lobby; B, W.C.; C, slop sink; D, bath; E, alternative position for W.C.; F, sink; G, linen; H, food; I, air-grating at floor level.

BLOCK PLAN A.



Scale—40 feet to 1 inch.

FIG. 80.—A, pavilion; B, administration-block; C, one-storey kitchen; D, isolation-block; E, lodge; F, future isolation-block; G, future boiler-house; H, mortuary etc., and laundry; I, future pavilion.

be placed in annexes separated from the wards by cross-ventilated lobbies. The closets should be water-closets where practicable; and the slop-sinks should be of an appropriate pattern adapted to receive the solid and liquid contents of bed-pans, the waste-pipe being 3 inches in diameter and arranged similarly to the soil-pipe of a water-closet.

The *out-offices* will comprise such buildings as laundry, disinfecting-chamber, mortuary, and ambulance-shed; and in large establishments a boiler-house and engine-house may be needed. Except in very small hospitals, the laundry should comprise a wash-house, a drying-closet, and an ironing-room. An apparatus should be provided for the disinfection by steam of bedding and articles which cannot be washed. The mortuary should be in a cool and unobtrusive position, and should be lighted from the north only.

A discharging-block is not unfrequently provided, consisting of an undressing-room, a bathroom, and a dressing-room, in which convalescents may take their final bath and put on clean clothes before leaving the hospital.

Each building which is to contain infected persons or things should be at least 40 feet distant from any of the other buildings.

The drains of each block should be trapped from the common drain and ventilated separately by an inlet just above the trap and by ventilating shafts at their highest points.

Block plan A (Fig. 80) illustrates the arrangement upon a rectangular site of about 2 acres of a hospital containing sixteen beds, in two ward-blocks with administration-block and out-offices; space being also reserved for future extensions. The best arrangement of the buildings will, however, in practice largely depend upon the shape and contour of the site.

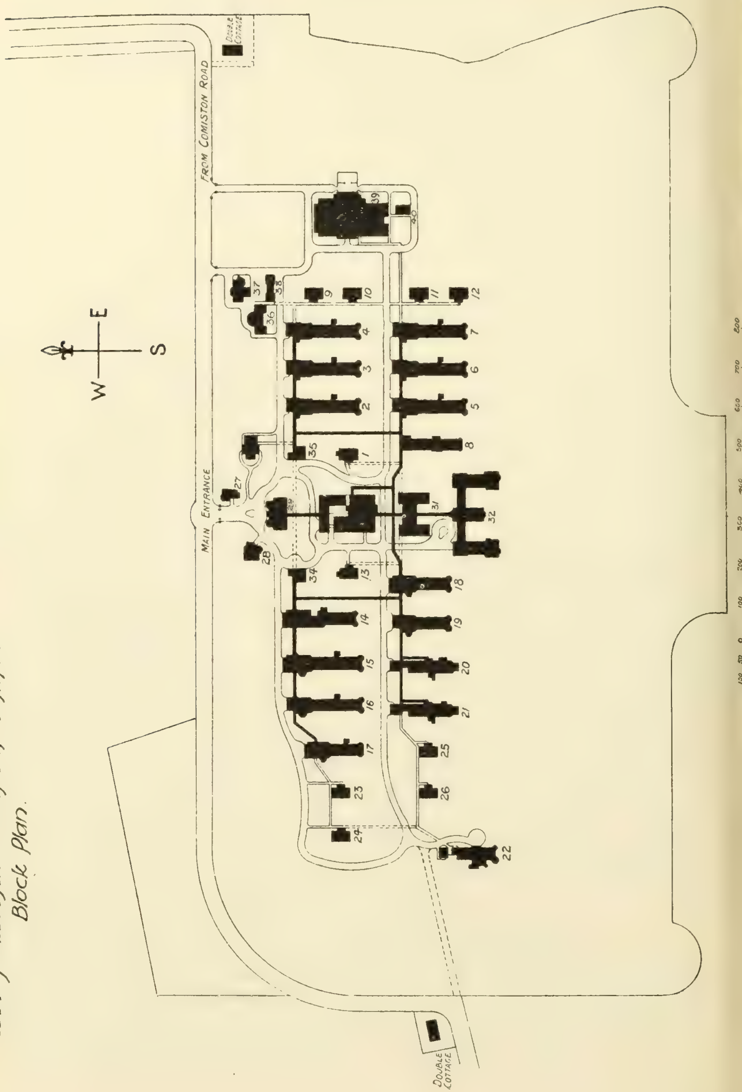
If, owing to the bleakness of the site, it is considered desirable that the several blocks should be connected by covered ways, these should not be enclosed, but should be open at the sides. A screen for protection against wind and driving rain may be provided if desired.

The City Isolation Hospital, Edinburgh.

This hospital is one of the largest of its kind in the kingdom and has been very carefully planned by those responsible for it, after visiting many of the most important hospitals in Europe, with a view to ascertain what was best from all points of view.

GROUND PLAN OF CITY HOSPITAL, COLINTON MAINS.

Observation. Nos. 1 and 13.	Scarlet Fever. Nos. 2, 3, 4, 5, 6, and 7.	Convalescent. No. 8.		Isolation. Nos. 9, 10, 11, 12, 23, 24, 25, and 26.
Diphtheria. No. 14.	Typhoid. Nos. 15 and 16.	Erysipelas. No. 17.		Measles. Nos. 18 and 19.
Whooping Cough. No. 20.	Chicken Pox. No. 21.	Typhus. No. 22.	Lodge. No. 27.	Superintendent's House. No. 28.
General Offices. No. 29.	Kitchen and Dining-rooms. No. 30	Servants' Home. No. 31.		Nurses' Home. No. 32.
Scarlet Discharge. No. 33.	Reception. Nos. 34 and 35.	Educational Block. No. 36.		Mortuary. No. 37.
Workshop. No. 38.	Laundry and Boiler-House No. 39.			Disinfector. No. 40.



CITY HOSPITAL - COLINTON MAINS.
Block Plan.

CITY ISOLATION-HOSPITAL, EDINBURGH.

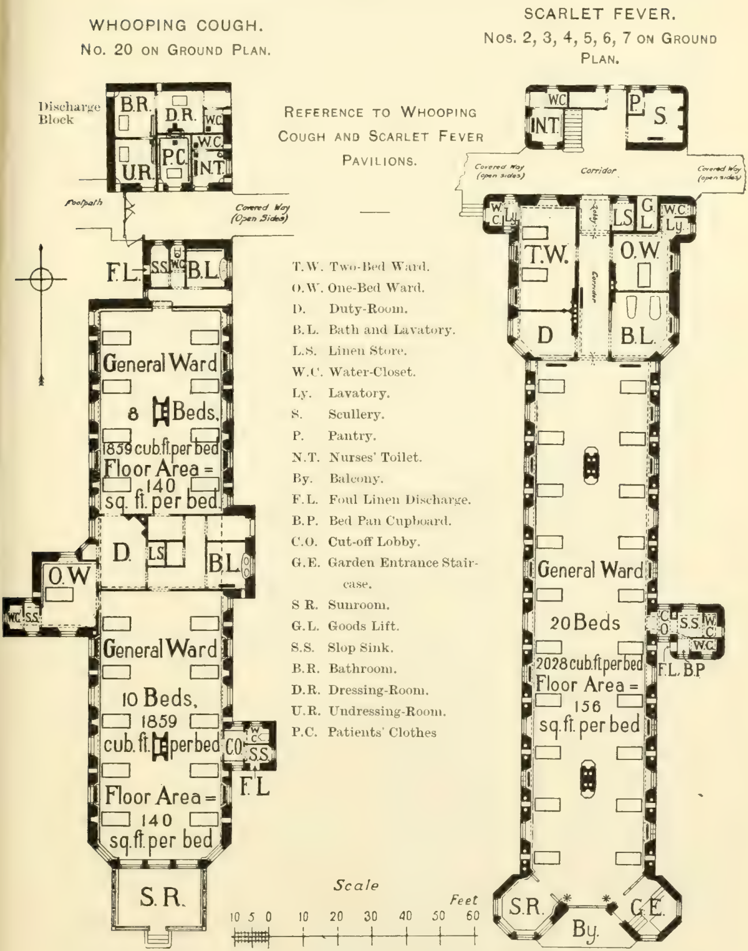


FIG. 82.—Typical ward plans.

Provision is made for 600 patients. This number includes private wards for patients who, for various reasons, it may be necessary to keep apart.

Two plans, typical of the general construction of the hospital, namely, one for whooping-cough and one for scarlet fever, are sufficiently explanatory, and show the arrangements for the reception, isolation, and ultimate discharge of the patients.

The hospital is equipped with a system of warming and ventilation of the most recent kind, and the cooking, laundry, and disinfecting appliances have been carefully thought out. Each pavilion has a separate recreation ground.

The designing, planning, and carrying out of the structural work has been under the superintendence of Mr. R. Morham, City Architect, who has kindly supplied the plans.

Hospitals for Small-pox.—In view of the frequently demonstrated liability of small-pox hospitals to disseminate that disease to neighbouring communities, and in order to lessen the risk of such occurrence, the Board require the following conditions to be complied with in the case of small-pox hospitals provided by means of loans sanctioned by them :—

1st. *The site must not have within a quarter of a mile of it either a hospital, whether for infectious diseases or not, or a workhouse, asylum, or any similar establishment, or a population of as many as* 200 *persons.*

2nd. *The site must not have within half a mile of it a population of as many as* 600 *persons, whether in one or more institutions, or in dwelling-houses.*

3rd. *Even where the above conditions are fulfilled a hospital must not be used at one and the same time for the reception of cases of small-pox and of any other class of disease.*

Small-pox.—Some circumstances in connection with the isolation of cases of small-pox call for observation.

Site.—The site of the hospital is an important matter. This should be *away* from dwellings, highways, public footpaths, and places of public resort, and it should be altogether independent in its administration of the hospital for other forms of infectious diseases.

These requirements make the selection of a site difficult, more especially as a large area of vacant land is necessary around it, approximately with a radius of 400 yards or upwards.

PAVILION No. 3.

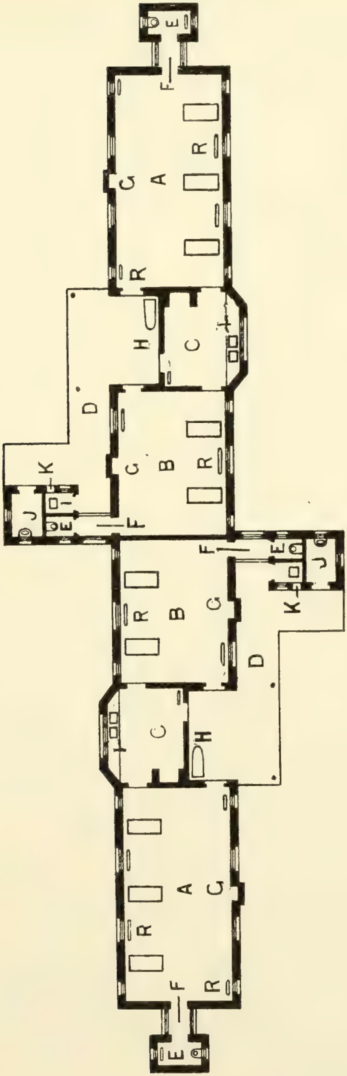


FIG. 83.—A, ward for three beds; B, ward for two beds; C, duty room; D, verandah; E, W.C.; F, lobby; G, fire; H, movable bath; I, sinks; J, robing-room; K, urine cupboard.

It must be remembered also that means must be taken to prevent this land from being encroached upon by buildings or dwellings in the future.

It is unlikely that small-pox can be conveyed long distances, say, a quarter of a mile to a mile, by aerial convection, and most cases of recent years, originally supposed to have been so caused by hospitals, have upon investigation proved to be due to direct or indirect contact with infected persons or things.

Construction.—The hospital should be constructed upon the pavilion system, and should contain a liberal margin to allow of the isolation of suspected cases, and it is also desirable to make provision for the temporary accommodation of persons who have been in intimate contact with the patient before removal. It is desirable that a city of 750,000 inhabitants should have available not less than 150 beds for the appropriate isolation of the incidental cases of small-pox which are liable to be imported, as well as for the isolation of those who have been in immediate contact with them, and also for suspected cases, and allowing some margin to meet emergencies which may arise.

The small-pox hospital at Fazakerley, Liverpool, consists of six pavilions (an isolation-block is shown by Fig. 83), so arranged as to meet the various purposes alluded to, and whilst capable of accommodating 180 patients, leaves abundant margin for extension.

The administrative-block is at some little distance from the wards, but the entire establishment is wholly independent of any other institution. The accompanying plan (Fig. 84) shows the administrative-block of the isolation-hospital at Southampton.

Administration.—With regard to the administration of a small-pox hospital, there are several points requiring attention in addition to those common to hospitals for ordinary infectious diseases. Perhaps the most important are :—

(*a*) The revaccination at the time of entering upon their duties of all persons engaged upon the premises, whether regularly or only temporarily at work, and no matter what the character of the occupation.

(*b*) The admission of visitors. It becomes necessary from time to time to admit visitors to patients in the hospital. This should be permitted only under urgent and exceptional conditions, such, for example, as those in

which the patient may be *in extremîs*. Visits should be minimised as far as possible, and the visitor should be required to be revaccinated (unless in the opinion of

ISOLATION-HOSPITAL, SOUTHAMPTON.

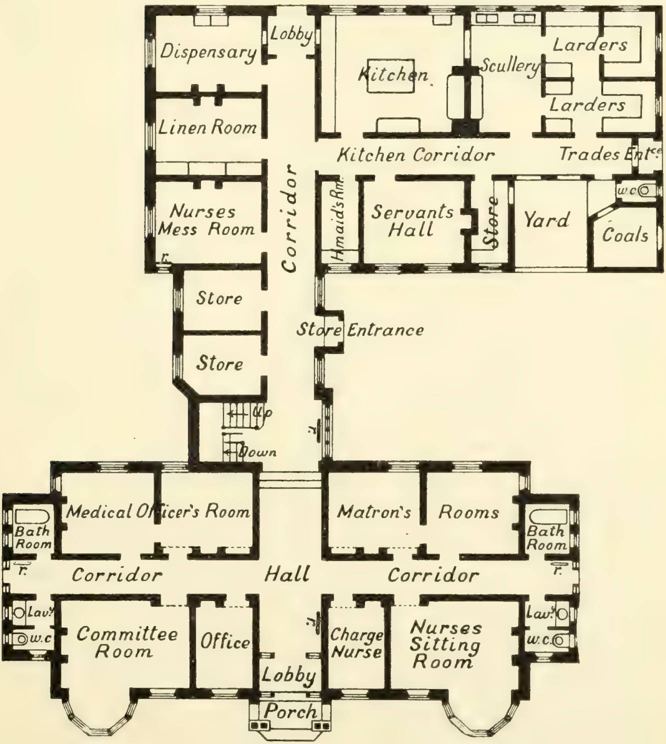


FIG. 84.—Ground floor plan of Administrative-Block.

the medical officer he is already protected), to put on suitable hospital clothing during the visit, and to take a good disinfecting bath, and resume clothing free from infection, before leaving. As an alternative he should be detained in the isolation section for fourteen days

after vaccination. Promiscuous visiting is wholly inadmissible. Every information as to progress of patients should be given to relatives and friends at a suitable place, in order to avoid the risk inseparable from visits to the hospital.

(*c*) No articles of any kind should be sent out from the hospital, and letters written by patients must be carefully disinfected by dry heat.

(*d*) Nurses and attendants off duty and on leave must take the usual precautions to guard against carrying out infection. Disinfecting baths should be taken, and clothing free from infection must be worn before mixing with their friends or the public.

It is frequently found that the small-pox hospital is an adjunct of the fever hospital, and is controlled from the same administrative-block. No doubt this plan is adopted for convenience and owing to the rarity of small-pox visitations; the arrangement cannot be altogether condemned in small districts. The expense and inconvenience attending the upkeep of a hospital for which perhaps for years there may be no use is not to be lost sight of. At the same time the arrangement is not one to be recommended.

It is a great safeguard to have abundance of room, not only for actual cases of small-pox, but for the isolation of doubtful cases, and for the complete isolation of families from which a case of small-pox has been taken.

This latter question leads to the consideration of providing special accommodation in quarantine houses where people may be kept under observation. There is clearly an advantage in removing them to wards connected with the hospital to which their relatives or friends have been taken, provided that they are willing to go and are well-conducted. If the wages of the bread-winners are paid there is usually very little difficulty on this head, and it is far better that this payment should be made rather than that grave risks should be incurred. There is no special advantage in obtaining large dwelling-houses, and transferring to these dweiling-houses families from which a case of small-pox has been taken. These families can be equally well revaccinated and kept under observation in their own homes in the manner already described.

The great object to aim at is to minimise as far as possible the means of communication with the public of persons who have been in intimate contact with small-pox patients. It is impossible to remove and isolate all who have been indirectly in contact, and indeed it is quite unnecessary that such a thing should be attempted.

Care, intelligence, and tact must be exercised in the matter, and it is not difficult to keep the people under observation without rendering that observation in any way irksome.

Disinfectants and Deodorants.

These terms are often used indiscriminately, but the latter simply act by disguising the smell, whilst there is good reason to believe that the former actually destroy the disease germs. Eau de Cologne is an example of the class deodorants, and Condy's Fluid of the class disinfectants.

The following remarks are an epitome of the article on disinfectants by Dr. Baxter, in the Reports of the Medical Officer of the Privy Council, 1875. The term disinfectant is still employed to designate agents possessing one or more of the following properties:—

1. That of checking or preventing certain chemical changes due to the operation of azotised ferments, and seemingly independent of the presence of living organisms. The word "catalysis" is used to specify, without in any way elucidating, the nature of such changes. Examples of them are furnished by the action of emulsin upon amygdalin, or diastase on starch, etc.
2. That of preventing or stopping decompositions, which are casually connected with the presence of organisms. Looked at from the biological rather than the chemical point of view, such changes naturally fall under at least two heads—viz. *fermentations*, occurring in acid media, and attended with the germination and multiplication of torula forms; and *putrefactions*, occurring in neutral or alkaline media, and associated with the presence and vital activity of schizomycetous organisms.
3. That of destroying the injurious products of any of the above processes, or of rendering them innocuous to man and the higher animals.
4. That of destroying the contagia of communicable diseases, or of depriving such contagia of their specific infective power.

The late Dr. Parkes gave the following as the best definition of the term "disinfectants":—"Those substances which can prevent infectious diseases from spreading, by destroying their specific poisons;" and these must be carefully distinguished

from "those agents which merely arrest the progress or absorb the offensive products of organic decomposition."

Dr. Baxter defines a "disinfectant" to be "any agent capable of so modifying the contagium of a communicable disease, during its transit from a sick to a healthy individual, as to deprive it of its specific power of infecting the latter."

Reasons for the discordance of opinion on the meaning of the term "disinfectant":—

1. Ignorance of the nature of contagium.
2. Ignorance of the power of any agent in destroying the specific virus, due to the difficulty in carrying out the necessary precautions, and watching results.
3. Preconceived notions of individuals as to the pathological nature of contagium. Germ theory, molecular change in albuminoid principles, etc., etc.

Disinfectants and Antiseptics.

The term *antiseptic* is generally applied to any substance which prevents the *origin* of a disease—*disinfectant* to any substance which prevents the *future spread* of a disease after it has begun. Antiseptics may act by oxidising the ferment directly—*e.g.*, permanganate of potash, indirectly—*e.g.*, chlorine and water; by chemical affinity as in the combination of carbolic acid with albumen, thus killing the micro-organisms which are protoplasmic bodies; and lastly the antiseptic may have a direct toxic action—corrosive sublimate, quinine, etc.

Dr. Baxter, from the experiments performed by him, has arrived at the following conclusions:—

1. That carbolic acid, sulphur dioxide, potassic permanganate, and chlorine are all of them endowed with true disinfectant properties, though in various degrees.
2. It is essential to bear in mind that antiseptic is not synonymous with disinfectant power, though as regards the four agents enumerated above, the one is, in a certain limited sense, commensurate with the other.
3. The value of chlorine and potassic permanganate appears to depend more on the nature of the medium through which the particles of infective matter are distributed, than on the specific characters of the particles themselves.
4. When either of these agents is used to disinfect a virulent liquid containing much organic matter, or any compounds capable of uniting

with chlorine, or of decomposing the permanganate, there is no security for the effectual fulfilment of disinfection short of the presence of free chlorine or undecomposed permanganate in the liquid after all chemical action has had time to subside.

5. A virulent liquid cannot be regarded as certainly and completely disinfected by sulphur dioxide unless it has been rendered permanently and strongly acid. The greater solubility of this agent renders it preferable, *cæteris paribus*, to chlorine and carbolic acid for the disinfection of liquid media.

6. No virulent liquid can be considered disinfected by carbolic acid unless it contain at least 2 per cent by weight of pure acid.

7. When disinfectants are mixed with a liquid, it is important to be sure that they are thoroughly incorporated with it, that no solid matters capable of shielding contagium from immediate contact with its destroyer be overlooked.

8. Aerial disinfection, as commonly practised in the sickroom, is either useless or positively objectionable, owing to the false sense of security it is calculated to produce. To make the air of a room smell strongly of carbolic acid, by scattering carbolic acid powder about the floor, or of chlorine, by placing a tray of chloride of lime in a corner, is, so far as the destruction of specific contagia is concerned, an utterly futile proceeding.

9. When aerial disinfection is used, chlorine and sulphur dioxide are, both of them, suitable agents ; the latter being the more effectual of the two. The place should be kept saturated by the gas for at least an hour, and longer if possible.

10. It is probable that all contagia disappear sooner or later under the influence of air and moisture, and that the absence of these influences may act as a preservative.

11. Dry heat, when it can be applied, is probably the most efficient of all disinfectants, care being taken that a sufficiently high temperature be maintained, that every portion of the article be subjected to the same temperature, and that the exposure to heat be prolonged for some time. A temperature of about 250° F. can be borne, without scorching, by most articles of dress.

NOTE.—Boiling water is perhaps as good or even a better disinfectant than dry heat. Super-heated steam under pressure has been lately suggested and advocated by Dr. H. F. Parsons. It has a greater penetrating power than hot air.

To these may be added the following from the Memorandum on Disinfection, issued by the Medical Officer to the Privy Council, 1866 :—

It is to cleanliness, ventilation, and drainage, and the use of perfectly pure drinking water, that populations ought mainly to look for safety against nuisance and infection. Artifical disinfectants cannot properly supply the place of these essentials ; for except in a small and peculiar class of cases, they are of temporary and imperfect usefulness.

CHAPTER IX.

SANITARY LAW.

The Local Government Board was constituted in 1871, and superseded the Poor Law Board. It is composed as follows:—A paid President appointed by His Majesty, all the principal Secretaries of State, the Lord Privy Seal and the Chancellor of the Exchequer, also a Parliamentary and a permanent Secretary. Attached to it are a Medical Officer, and several medical, legal, and scientific Inspectors. It is the Central Authority, and is the Court of Appeal from all Local Authorities, and can be addressed by memorials from all parts of the country. The Board takes charge of the registration of births, deaths, and marriages, and of all matters that appertain to the public health, such as drainage, the prevention and arrest of epidemics, the improvement of towns; and on it also rests the powers formerly exercised by the Board of Trade with regard to the enforcement of the provisions of Alkali Acts. By Provisional Order it can make or unmake Sanitary Districts. These Provisional Orders are of no force till confirmed by Parliament, when they become virtually Acts of Parliament. They are granted by the Local Government Board on petition by the Local Authority, are introduced into a Bill, and, if not opposed, are carried through both Houses by the Local Government Board. If opposed, they become subject to all the vicissitudes of a private Bill. The Board can take the initiative in sanitation, and can appoint Medical Officers to visit and report on the condition of any place, if necessary; and it also controls the salaries of Medical Officers of Health, when any part of the salary is paid by the Crown. Most of the Medical Officers of Health are, however, paid solely by the

Local Authorities, who have then the power of controlling the salary, engagement, and dismissal of the Medical Officer.

Local Authorities.—For sanitary purposes, in England the country is divided into Urban and Rural Sanitary Authorities. The Town Council, Improvement Commissioners, and Local Board for the one, and the Union for the other, are the Local Authorities of their respective districts. According to the Public Health (Scotland) Act, 30 and 31 Vict., c. 101, the following bodies shall respectively be the Local Authority to execute this Act:—

In places within the jurisdiction of any Town Council, and not subject to the jurisdiction of Police Commissioners or Trustees, as after mentioned—the Town Council.

In places within the jurisdiction of Police Commissioners under any General or Local Act—the Police Commissioners.

In any parish or part thereof, over which the jurisdiction of a Town Council, or of Police Commissioners, or Trustees exercising the functions of Police Commissioners, does not extend—the Parochial Board of such parish.

Summary of Sanitary Legislation.

The supreme authority in sanitary matters is the Local Government Board, to which body have been transferred powers formerly exercised by the Privy Council, by the Poor Law Board, or by the Secretary of State.

It controls the acts of Local Authorities, regulates borrowing powers, holds inquiries and investigations, and its representatives may attend meetings of Local Boards.

Public Health Act.

This is the most important of the Sanitary Acts of Parliament. The Act was passed in 1875, and many additions have been made to it since. The chief sanitary provisions which affect the Medical Officer of Health are the following:—

Sections 13 *to* 33 empower the Local Authority to construct and control sewers, and require that sewage be purified before entering streams. Works may be constructed for the disposal of sewage, provided that no nuisance be created by the exercise of these powers.

Sections 35 *to* 41 provide for suitable privy or closet accommodation, both in dwellings and in factories, and a penalty of £20 for constructing buildings without such accommodation.

The proper provision and conduct of public urinals and closets is also dealt with.

Under *Sections* 42 *to* 45 the Local Authority is required to deal with the removal of house refuse, and for cleansing and watering streets, either undertaking the work itself or arranging for it to be done by contract.

Section 46 provides that the Local Authority may, on the certificate of the Medical Officer of Health, or two practitioners, to the effect that any house, or part thereof, is in such a filthy condition that health is endangered, cause the owner to cleanse and purify it.

Sections 51 *to* 56 empower Local Authorities to provide water supply, to construct, maintain, and purchase water works, wells, etc., and to charge water rents, water rates, etc. The sections also enable Local Authorities to provide water for baths, trades, fire-plugs, mains, etc.

Under *Section* 68 a penalty of £200 may be inflicted for fouling any water supply.

Sections 71 *to* 75 prohibit the construction of cellar dwellings, and require that all existing cellar dwellings shall be not less than 7 feet in height, 3 feet of which must be above the surface of the street. The cellar must also have an open area of at least 2 feet 6 inches, and be effectually drained and provided with closet and ash-box. Each cellar must have a fireplace and chimney, and the window made to open. Penalty for contravention, 20s. Any cellar in which any person passes the night shall be deemed to be occupied as a dwelling.

Sections 76 *to* 89 deal with common lodging-houses, and authorise the Sanitary Authority to make and enforce bye-laws to prevent overcrowding, and for the separation of the sexes, and for registration, inspection, and cleanliness.

The following rules and instructions are in force in Liverpool :—

1. No greater number than   lodgers are to be received or accommodated in this house at any one time.

2. The windows of every sleeping-room in this house are to be opened, and kept open to their full width, from nine to ten o'clock every morning, and from two to three o'clock every afternoon (weather permitting), unless in case of sickness in any room requiring the windows to be closed.

3. The floors of every room in this house shall be well

swept every morning before the hour of ten, and shall be well washed during the morning of every Friday.

4. This house shall be thoroughly cleansed, and the walls and ceiling of every room in this house shall be well and sufficiently limewashed, and the blankets, rugs, and bed-clothes, and covers used in this house, shall be thoroughly cleansed and scoured in the first week of each of the months of April, August, and December.

5. Upon any person in this house, whether a lodger or one of the family, being affected with fever or any contagious or infectious disorder, the keeper shall forthwith give notice thereof to the Medical Officer of Health at his office, Municipal Offices, Dale Street, and the Medical Officer will visit the house, and take such proceedings as he shall think proper in compliance with the Act.

6. If any person in this house shall be affected with fever or any infectious or contagious disorder, the blankets and bed-clothes used by such person shall be thoroughly cleansed and scoured, and the bedding fumigated, immediately after the removal of such person, and where the bedding used consists of shavings or straw, the same shall be burned immediately after such removal.

7. The keeper of this house shall provide sufficient accommodation for washing, together with a sufficient supply of water for the use of the lodgers herein.

8. The keeper of this house shall reduce the number of lodgers, or shall cease to receive and accommodate lodgers altogether, immediately upon receiving notice to that effect from the Medical Officer of Health.

9. This ticket shall be placed and kept in such situation in this house as the Medical Officer of Health shall from time to time direct, and shall be produced and delivered to such officer on demand.

N.B.—The keeper of any lodging-house defacing or removing this ticket or disobeying the above rules and instructions, will be liable to the several penalties in that behalf provided by the bye-laws for regulating lodging-houses, a copy whereof may be obtained on application at the Office of the Town Clerk, at the Municipal Offices, Dale Street.

Section 90 relates to sub-let houses.

Bye-laws are made by the Sanitary Authority—

For fixing the number of persons who may occupy a house or part of a house which is let in lodgings, or occupied by members of more than one family;

For the registration of houses so let or occupied;

For the inspection of such houses;

For enforcing the provision of privy accommodation for such houses, and for promoting the cleanliness and ventilation in such houses;

For the cleansing and lime-washing at stated times of the premises, and for the paving of the courts and courtyards thereof;

For the giving of notices and the taking of precautions in case of any infectious disease.

Sections 91 *and* 92 are very important ones, dealing with nuisances of any kind, such as, premises in such a state as to be a nuisance, foul ditches, drains, ashpits, etc., animals, accumulations of filth, overcrowding of house, or part of house, whether or not by members of the same family, nuisances from defective ventilation, smoky chimneys, etc. Penalties, 40s.

Under Section 97 an insanitary house must be closed until rendered fit for occupation.

Under Section 110 ships may be dealt with in the same way as a house.

Sections 112 *to* 115 prevent the establishment of an offensive trade, without the consent in writing of the Local Authority, under a penalty of £50.

The Urban Authority may make bye-laws regulating offensive trades.

Under Sections 116 *to* 119 the Medical Officer or Inspector may examine any meat, flesh, fish, fruit, vegetables, or other food exposed or deposited for sale, and intended for the food of man, and seize any which appears to be unfit for the food of man, in order to have it dealt with by a magistrate, the onus of proof that it was not intended for the food of man lying with the party charged. These sections, it will be observed, do not impose the obligation upon the Inspector of telling the dealer whether the food is sound or unsound, but he merely has to seize it and have it dealt with by a magistrate. Penalty, £20 or three months' imprisonment.

Sections 120 *to* 130 deal with infectious diseases. They enable the Local Authority to serve notice upon owners or occupiers, to cleanse and disinfect an infected house, to destroy

infected articles and give compensation for them ; to maintain disinfecting stations and ambulance carriages, and remove to hospital any person suffering from a dangerous infectious disease, and who is without proper lodging and accommodation, or on board ship. The penalty for obstruction is £10.

For exposing an infected person or thing in a public street the penalty is £5.

For letting infected rooms or house, without previous disinfection to the satisfaction of a medical man, the penalty is £20 ; and if the person letting the rooms is asked by the person taking the rooms, and a false statement is made, the penalty may then be one month's imprisonment with hard labour.

The Local Government Board may make special regulations at epidemic times.

Section 131 authorises the provision of temporary or permanent hospitals for infectious diseases.

Sections 141 *to* 143 provide for proper mortuary accommodation, and the removal thereto of bodies for post-mortem examination.

Food and Drugs Act.

The Food and Drugs Act deals with articles of food, and all drugs, whether for internal or external use.

It prohibits the mixing of injurious ingredients with any food or drug with intent to sell or selling, under a penalty of £50, or six months' hard labour for a second offence. The offender is exempt if he can prove absence of knowledge, and show that such knowledge could not with reasonable diligence be obtained.

An important clause in this Act is *Clause* 6, which provides that no person shall sell, to the prejudice of the purchaser, any article of food, or any drug, which is not of the nature, quality, and substance of the article demanded by such purchaser, under a penalty of £20.

The mixing of a non-injurious ingredient to preserve an article, and not to fraudulently increase the bulk or conceal inferior quality, is an exemption.

The Act authorises the appointment of analysts, and the purchase of samples.

When a sample is purchased for analysis by an officer, the officer must offer to divide it into three parts, sealing up each

one. One to be handed back to the vendor, one taken to the analysts, and the third produced in court, in the event of a dispute arising about the other two samples. The third portion is sent to Somerset House for analysis.

Factory and Workshops Act.

Under the *Factory and Workshops Act of* 1901, the sanitary condition of factories and workshops is dealt with. The ventilation, drainage, temperature, sanitary conveniences for each sex, come within this Act.

The sanitary condition of bakehouses is also controlled by this Act. No underground bakehouse, *i.e.* a bakehouse any part of which is three feet below the level of the street, can be legally used unless it was used as a bakehouse at the passing of this Act ; and after the 1st January 1904 no underground bakehouse may be legally used unless certified by the District Council to be suitable for that purpose. Every bakehouse must be supplied with water, must have suitable closet accommodation apart from the bakehouse. Every bakehouse must be periodically limewashed, painted, or washed, and no place on the same level as the bakehouse and forming part of the same building may be used as a sleeping place, unless it is effectually separated from the bakehouse, and has adequate lighting and ventilation. Penalty for contravention, £5.

Extract from the Factory and Workshop Act, 1901, relating to Underground Bakehouses.

Section 101.—(1) An underground bakehouse shall not be used as a bakehouse unless it was so used at the passing of this Act.

(2) Subject to the foregoing provision, after the first day of January, 1904, an underground bakehouse shall not be used unless certified by the district council to be suitable for that purpose.

(3) For the purpose of this section an underground bakehouse shall mean a bakehouse, any baking room of which is so situate that the surface of the floor is more than three feet below the surface of the footway of the adjoining street, or of

the ground adjoining or nearest to the room. The expression "baking room" means any room used for baking, or for any process incidental thereto.

(4) An underground bakehouse shall not be certified as suitable unless the district council is satisfied that it is suitable as regards construction, light, ventilation, and in all other respects.

(6) If any place is used in contravention of this section, it shall be deemed to be a workshop not kept in conformity with this Act.

(7) In the event of the refusal of a certificate by the district council, the occupier of the bakehouse may, within twenty-one days from the refusal, by complaint apply to a court of summary jurisdiction, and if it appears to the satisfaction of the court that the bakehouse is suitable for use as regards construction, light, ventilation, and in all other respects, the court shall thereupon grant a certificate of suitability of the bakehouse, which shall have effect as if granted by the district council.

Housing of the Working Classes Act, 1890.

The procedure under Part I. of this Act for clearing an insanitary area is as follows:—

1. The Medical Officer of Health must make a report (or, as it is called in the Act, "an official representation") to the Sanitary Authority that a certain area, *considered as a whole*, is unhealthy, and can only be made sanitary by demolition and reconstruction.

2. If the Sanitary Authority be satisfied of the truth of the official representation, they must prepare an Improvement Scheme, showing the area to be dealt with and the property to be demolished, with proper plans to illustrate the same.

3. The Sanitary Authority then proceed to obtain a Provisional Order to acquire compulsory powers to obtain the properties included in the scheme.

4. The Improvement Scheme shall provide for the erection of such number of workmen's dwellings in place of those demolished as shall satisfy the Local Government Board.

It is of importance to note that in prescribing an "unhealthy area" and preparing an Improvement Scheme it is not necessary that every building in the prescribed area should be

insanitary, or, in fact, used as a dwelling-house at all All that is required is for the Medical Officer of Health to report that a certain area is, *taken as a whole*, unhealthy; and then every building within that area can be dealt with under the scheme.

Of course, a sanitary building, such as a manufactory or business premises, might be expressly excluded from the scheme, if such exclusion did not interfere with the ultimate idea and plan of rebuilding.

The cost of obtaining a Provisional Order would depend upon whether the scheme passed through Parliament unopposed, or was opposed; but if a scheme of sufficient magnitude were adopted the cost of obtaining the compulsory powers would not be appreciable.

Part II. of the Housing of the Working Classes Act, 1890, provides that where "a dwelling-house is in a state so dangerous or injurious to health as to be unfit for human habitation," proceedings can be taken under Sections 91, 94, 95, and 97 of the Public Health Act, 1875, before the Magistrates to obtain a "closing order" (see Section 32). Upon such an order being made, the house must be kept closed until rendered fit for habitation. If it is not made fit, or is incapable of being made fit, the Corporation may order the same to be demolished (subject to the owner's right of appeal).

Part III. of the Act provides for the acquisition of land by agreement (or compulsorily on the Corporation obtaining a Provisional Order) for the purpose of building workmen's dwellings thereon, and land can (with the sanction of the Local Government Board) be appropriated for that purpose.

Part III. of the Act also contains power for the Local Authority to erect workmen's dwellings on the land so acquired or appropriated.

By the Housing of the Working Classes Act, 1900, the Local Authority is empowered to establish or acquire houses for the working classes under Part III. of the Act of 1890 outside their district, thus enabling the workers to live away from the congested parts of cities.

The Public Health Act, 1875.

INFECTIOUS DISEASES AND HOSPITALS.

Any Local Authority on the certificate of their Medical Officer of Health, or of *any other* legally qualified medical practitioner, stating that a house requires disinfecting and cleansing, or any articles therein likely to retain infection, shall give notice in writing to the owner or occupier, requiring him to cleanse and disinfect such house and articles within a specified time. If the person fail to comply therewith, he shall be liable to a penalty of not less than one shilling, and not exceeding ten shillings, for every day during which he continues to make default; and the L. A. shall cause such house, or part thereof, and articles, to be cleansed and disinfected, and may recover the expenses incurred from the owner or occupier. Where the owner or occupier of any such house is, from poverty or otherwise, unable to carry out the requirements of this Section, the L. A. may, with his consent, cleanse and disinfect such house and articles, and defray the expenses thereof.

Any L.A. may direct the destruction of any bedding, clothing, or other articles which have been exposed to infection from any dangerous infectious disorder, and may give compensation for the same.

And may also provide a proper place, with all necessary apparatus and attendance, for the disinfection of bedding, clothing, or other articles which have become infected, and may cause any articles brought for disinfection to be disinfected free of charge.

Any L. A. may provide and maintain a carriage or carriages suitable for the conveyance of persons suffering under any infectious disorder, and may pay the expense of conveying therein any person so suffering to an hospital or other place of destination.

Where any suitable hospital or place for the reception of the sick is provided within the district of a L. A., or within a convenient distance, any person suffering from any dangerous infectious disorder, and is without proper lodging or accommodation, or lodged in a room occupied by more than one family, or is on board any ship or vessel, may, on a certificate signed by a *legally qualified medical practitioner*, and with the consent of the superintending body of such hospital, be removed, by order of any justice, to such hospital or place at the cost of the L. A.; and any person so suffering, who is lodged in any common lodging-house, may, with the like consent and on a like certificate, be so removed by order of the L. A.

Any person who wilfully disobeys or obstructs the execution of such order shall be liable to a penalty not exceeding ten pounds.

Any person who—

1. While suffering from any dangerous infectious disorder, wilfully exposes himself without proper precautions against spreading the disorder in any street, public place, or enters any public conveyance without previously notifying to the owner, conductor, or driver thereof that he is suffering; or,
2. Being in charge of any person so suffering, so exposes such sufferer; or,
3. Gives, lends, sells, transmits, or exposes, without previous disinfection, any bedding, clothing, rags, or other things which have been exposed to infection from any such disorder;

shall be liable to a penalty not exceeding five pounds; and a person who, while suffering from any such disorder, enters any public conveyance without previously notifying to the owner or driver that he is so suffering, shall in addition be ordered by the Court to pay such owner and driver the amount of any loss or expense they may incur in carrying into effect the provisions of this Act with respect to disinfection of the conveyance.

Provided that no proceedings shall be taken against persons transmitting with proper precautions any bedding, clothing, rags, or other things, for the purpose of having the same disinfected. Every owner or driver of a public conveyance shall immediately provide for the disinfection of such conveyance after it has, to his knowledge, conveyed any person suffering from a dangerous infectious disorder; and if he fail to do so he shall be liable to a penalty not exceeding five pounds; but no such owner or driver shall be required to convey any person so suffering until he has been paid a sum sufficient to cover any loss or expense incurred by him in carrying into effect the provisions of the section. Any person who, knowingly, lets for hire any house, room, or part of a house, in which any person has been suffering from any dangerous infectious disorder, without having such house, room, or part of a house, and all articles liable to retain infection, disinfected to the satisfaction of a legally qualified medical practitioner, as testified by a certificate signed by him, shall be liable to a penalty not exceeding twenty pounds. For the purpose of this Section, the keeper of an inn shall be deemed to let for hire part of a house to any person admitted as a guest into such inn. Any person letting for hire, or showing for the purpose of letting for hire, any house or part of a house, who, on being questioned by any person negotiating for the hire of such house, or part of a house, as to the fact of there being, or within six weeks previously having been, any person suffering from any dangerous infectious disorder, knowingly makes a false answer to such question, shall be liable, at the discretion of the Court, to a penalty not exceeding twenty pounds, or to imprisonment, with or without hard labour, for a period not exceeding one month.

MORTUARIES, ETC.

Any L. A. may, and if required by Local Government Board, shall provide and fit up a proper place for the reception of dead bodies before interment, and may make by-laws with respect to the management and charges for use of the same; they may also provide for the decent and economical interment of any dead body which may be received into a mortuary. Where the body of one who has died of any infectious disease is retained in a room in which persons live or sleep, or any dead body which is in such a state as to endanger the health of the inmates of the same house or room is retained in such a house or room, any justice may, on a certificate signed by a *legally qualified medical practitioner*, order the body to be removed, at the cost of the L. A., to any mortuary provided by such L. A., and direct the same to be buried within a time to be limited in such order; and unless the friends and relations of the deceased undertake to bury the body within the time so limited, and do bury the same, it shall be the duty of the relieving

officer to bury such body at the expense of the poor rate, but any expense so incurred may be recovered by the relieving officer from any person legally liable to pay the expense of such burial. Any person obstructing the execution of an order made by a justice under this Section, shall be liable to a penalty not exceeding five pounds. Any L. A. may provide and maintain a proper place (otherwise than at a workhouse or a mortuary) for the reception of dead bodies during the time required to conduct any *post-mortem* examination ordered by a coroner or other constituted authority, and may make regulations with respect to the management of such place ; and where any such place has been provided, a coroner or other constituted authority may order the removal of the body to and from such place for carrying out such *post-mortem* examination, such costs of removal to be paid in the same manner and out of the same fund as the costs and fees for *post-mortem* examinations when ordered by the coroner.

Regulations substituted for the Repealed Quarantine Acts

Non-indigenous infectious diseases which are liable to be imported into the country, namely, Cholera, Yellow Fever, and Plague, are dealt with under special orders of the Local Government Board, the late Quarantine Acts having been entirely repealed in August 1896.

Under the existing regulations the ship is dealt with pretty much as a house would be dealt with under similar circumstances, *i.e.* the sick are removed to hospital, all infected articles are disinfected or destroyed, the vessel is also disinfected ; the names and addresses of all persons who have been in contact with the sick person are taken, and the sanitary authorities of the districts to which the persons are going are informed of the facts, and are thus enabled to take precautionary measures. No one is allowed to land who does not give this information.

Vessels coming from infected ports, or on which during the voyage infectious sickness has been, fly a special signal, and are visited by the Medical Officer of the port.

A mooring station is appointed in each port, and if necessary the vessel is ordered to the mooring station. This would only be necessary in the event of the vessel being infected, *i.e.* having a case or cases of Cholera, Yellow Fever, or Plague on board.

Any person certified by the Medical Officer of Health to be suffering from any illness which such officer suspects may prove to be Cholera, Yellow Fever, or Plague, may be detained either

on board or in hospital for two days, in order to give time for the diagnosis to be confirmed.

The master of the ship is required to give every assistance to the Medical Officer, and the penalty for infringement of the terms of the Order is £100, and £50 per day for every day during which the offence continues.

CANAL BOATS.

THE FOLLOWING ARE THE REGULATIONS MADE BY THE LOCAL GOVERNMENT BOARD, IN ACCORDANCE WITH THE REQUIREMENTS OF THE CANAL BOATS ACT, 1877 (40 AND 41 VICT. C. 60).

For fixing the number, age, and sex of the persons who may be allowed to dwell in a canal boat, having regard to the cubic space, ventilation, provision for the separation of the sexes, general healthiness, and convenience of accommodation of the boat.

8. For the above purpose the following Rules shall apply:—

(*a*) In the cabin or cabins of the boat there shall be not less than 60 cubic feet of free air space for each person above the age of twelve years, and not less than 40 cubic feet of free air space for each child under the age of twelve years.

In boats built prior to 30th of June 1878, the free air space for each child under the age of twelve years, may be not less than 30 cubic feet.

In the case of a "fly" boat, worked by four persons above the age of twelve years, there shall be not less than 180 cubic feet of free air space in any cabin occupied as a sleeping-place by any two of such persons at the same time.

(*b*) A cabin occupied as a sleeping-place by a husband and wife shall not, while in such occupation, be occupied as a sleeping-place by any other person of the female sex above the age of twelve years, or by any other person of the male sex above the age of fourteen years.

In the case of a boat built prior to the 30th June 1878, a cabin, occupied as a sleeping-place by a husband and wife, may be occupied by one other person of the male sex above the age of fourteen years, subject to the following conditions:—

1. That the cabin be not occupied as a sleeping-place by any other person than those above mentioned; and
2. That the part of the cabin which may be used as a sleeping-place by the husband and wife shall, at all times while in actual use, be effectually separated from the part used as a sleeping-place by the other occupant of the cabin, by means of a sliding or otherwise moveable screen or partition of wood or other solid material, so constructed or placed as to provide for efficient ventilation.

(*c*) A cabin occupied as a sleeping-place by a person of the male sex above the age of fourteen years, shall not, at any time, be occupied as a sleeping-place by a person of the female sex above the age of twelve years, unless she be the wife of the male occupant, or of one of the male occupants, in any case within the proviso to Rule (*b*).

DUTIES OF A MEDICAL OFFICER OF HEALTH.

The following shall be the duties of the Medical Officer of Health in respect of the Sanitary district for which he is appointed; or if he shall be appointed for more than one district, or for a part of a district, then in respect of each of such districts or of such part:—

1. He shall inform himself, as far as practicable, respecting all influences affecting, or threatening to affect, injuriously the public health within the district.

2. He shall inquire into and ascertain, by such means as are at his disposal, the causes, origin, and distribution of diseases within the district, and ascertain to what extent the same have depended on conditions capable of removal or mitigation.

3. He shall, by inspection of the district, both systematically at certain periods, and at intervals as occasion may require, keep himself informed of the conditions injurious to health existing therein.

4. He shall be prepared to advise the Sanitary Authority on all matters affecting the health of the district, and on all sanitary points involved in the action of the Sanitary Authority or Authorities; and, in cases requiring it, he shall certify, for the guidance of the Sanitary Authority or of the Justices, as to any matter in respect of which the certificate of a Medical Officer of Health or a medical practitioner is required as the basis, or in aid, of sanitary action.

5. He shall advise the Sanitary Authority on any question relating to health involved in the framing and subsequent working of such by-laws and regulations as they may have power to make.

6. On receiving information of the outbreak of any contagious, infectious, or epidemic disease of a dangerous character within the district, he shall visit the spot without delay, and inquire into the causes and circumstances of such outbreak, and advise the persons competent to act as to the measures which may appear to him to be required to prevent the extension of the disease, and, so far as he may be lawfully authorised, assist in the execution of the same.

7. On receiving information from the Inspector of Nuisances that his intervention is required in consequence of the existence of any nuisance injurious to health, or of any overcrowding in a house, he shall, as early as practicable, take such steps, authorised by the Statutes in that behalf, as the circumstances of the case may justify and require.

8. In any case in which it may appear to him to be necessary or advisable, or in which he shall be so directed by the Sanitary Authority, he shall himself inspect and examine any animal, carcase, meat, poultry,

game, flesh, fish, fruit, vegetables, corn, bread, or flour, exposed for sale, or deposited for the purpose of sale or preparation for sale, and intended for the food of man, which is deemed to be diseased, or unsound, or unwholesome, or unfit for the food of man, and if he find that such animal or article is diseased, or unsound, or unwholesome, or unfit for the food of man, he shall give such directions as may be necessary for causing the same to be seized, taken and carried away, in order to be dealt with by a Justice according to the provisions of the Statutes applicable to the case. This regulation is confirmed by the Public Health Act, 1875. See also Public Health (Scotland) Act, 1867, Public Health (Ireland) Act, 1874.

9. He shall perform all the duties imposed upon him by any by-laws and regulations of the Sanitary Authority, duly confirmed, in respect of any matter affecting the public health, and touching which they are authorised to frame by-laws and regulations.

10. He shall inquire into any offensive process of trade carried on within the district, and report on the appropriate means for the prevention of any nuisance or injury to health therefrom.

11. He shall attend at the office of the Sanitary Authority, or at some other appointed place, at such stated times as they may direct.

12. He shall from time to time report, in writing, to the Sanitary Authority his proceedings, and the measures which may require to be adopted for the improvement or protection of the public health in the district. He shall in like manner report with respect to the sickness and mortality within the district, so far as he has been enabled to ascertain the same.

13. He shall keep a book or books, to be provided by the Sanitary Authority, in which he shall make an entry of his visits, and notes of his observations and instructions thereon, and also the date and result of the action taken thereon, and of any action taken on previous reports, and shall produce such book or books, whenever required, to the Sanitary Authority.

14. He shall also prepare an Annual Report, to be made at the end of December in each year, comprising tabular statements of the sickness and mortality within the district, classified according to diseases, ages, and localities, and a summary of the action taken during the year for preventing the spread of disease. The report shall also contain an account of the proceedings in which he has taken part, or advised, under the Sanitary Acts, so far as such proceedings relate to conditions dangerous or injurious to health, and also on account of the supervision exercised by him, or on his advice, for sanitary purposes, over places and houses that the Sanitary Authority has power to regulate, with the nature and results of any proceedings which may have been so required and taken in respect of the same, during the year. It shall also record the action taken by him, or on his advice, during the year, in regard to offensive trades, bakehouses, and workshops.

15. He shall give immediate information to the Local Government Board of any outbreak of dangerous epidemic disease within the district, and shall transmit to the Board, on forms to be provided by them, a quarterly return of the sickness and deaths within the district, and also a copy of each annual and of any special report.

16. In matters not specially provided for in this Order, he shall observe and execute the instructions of the Local Government Board on the duties of Medical Officers of Health, and all the lawful orders and directions of the Sanitary Authority applicable to his office.

DUTIES OF INSPECTORS OF NUISANCES.

The following shall be the duties of the Inspector of Nuisances, as laid down by an Order of the Local Government Board, March 1880, in respect of the district for which he is appointed, or if he shall be appointed for more than one district, then in respect of each of such districts :—

1. He shall perform, either under the special directions of the Sanitary Authority, or (so far as authorised by the Sanitary Authority) under the directions of the Medical Officer of Health, or in cases where no such directions are required, without such directions, all the duties specially imposed upon an Inspector of Nuisances by the Sanitary Acts, or by the orders of the Local Government Board.

2. He shall attend all meetings of the Sanitary Authority when so required.

3. He shall, by inspection of the district, both systematically at certain periods, and at intervals as occasion may require, keep himself informed in respect of the nuisances existing therein that require abatement under the Sanitary Acts.

4. On receiving notice of the existence of any nuisance within the district, or of the breach of any by-laws or regulations made by the Sanitary Authority for the suppression of nuisances, he shall, as early as practicable, visit the spot, and inquire into such alleged nuisance or breach of by-laws or regulations.

5. He shall report to the Sanitary Authority any noxious or offensive business, trades, or manufactories established within the district, and the breach or non-observance of any by-laws or regulations made in respect of the same.

6. He shall report to the Sanitary Authority any damage done to any works of water supply, or other works belonging to them, and also any case of wilful or negligent waste of water supplied by them, or any fouling by gas, filth, or otherwise, of water used for domestic purposes.

7. He shall, from time to time, and forthwith upon complaint, visit and inspect the shops and places kept or used for the sale of butchers' meat, poultry, fish, fruit, vegetables, corn, bread, or flour, or as a slaughter-house, and examine any animal, carcase, meat, poultry, game, flesh, fish, fruit, vegetables, corn, bread, or flour, which may be therein ; and in case any such article appear to him to be intended for the food of man, and to be unfit for such food, he shall cause the same to be seized ; and take such other proceedings as may be necessary in order to have the same dealt with by a Justice : Provided that in any case of doubt arising under this clause, he shall report the matter to the Medical Officer of Health, with the view of obtaining his advice thereon.

8. He shall, when and as directed by the Sanitary Authority, procure and submit samples of food or drink, and drugs suspected to be adulterated, to be analysed by the analyst appointed under the Adulteration of Food Act, 1872; and upon receiving a certificate stating that the articles of food or drink, or drugs, are adulterated, cause a complaint to be made, and take the other proceedings prescribed by that Act.

9. He shall give immediate notice to the Medical Officer of Health of the occurrence within his district of any contagious, infectious, or epidemic disease of a dangerous character; and whenever it appears to him that the intervention of such officer is necessary in consequence of the existence of any nuisance injurious to health, or of any overcrowding in a house, he shall forthwith inform the Medical Officer thereof.

10. He shall, subject in all respects to the directions of the Sanitary Authority, attend to the instructions of the Medical Officer of Health with respect to any measures which can be lawfully taken by him under the Sanitary Acts for preventing the spread of any contagious, infectious, or epidemic disease of a dangerous character.

11. He shall enter, from day to day, in a book to be provided by the Sanitary Authority, particulars of his inspections, and the action taken by him in the execution of his duties. He shall also keep a book, or books, to be provided by the Sanitary Authority, so arranged as to form, as far as possible, a continuous record of the sanitary condition of each of the premises in respect of which any action has been taken under the Sanitary Act, and shall keep any other systematic records that the Sanitary Authority may require.

12. He shall, at all reasonable times, when applied to by the Medical Officer of Health, produce to him his books, or any of them, and render to him such information as he may be able to furnish with respect to any matter to which the duties of Inspector of Nuisances relate.

13. He shall, if directed by the Sanitary Authority to do so, superintend and see to the due execution of all works which may be undertaken under their direction for the suppression or removal of nuisances within the district.

14. In matters not specifically provided for in this Order, he shall observe and execute all the lawful orders and directions of the Sanitary Authority, and the orders of the Local Government Board which may be hereafter issued applicable to his office.

NUISANCES.—A nuisance at common law is "anything which worketh hurt, inconvenience, or damage to any one." Under the Public Health Act, 1875, the term is confined to those matters which are injurious to health.

THE INFECTIOUS DISEASE (PREVENTION) ACT, 1890.

The above Act authorises the inspection of dairies in certain cases, and gives power to prohibit the sale of milk from any dairy situate within or without the district if the Medical

Officer is of opinion that the consumption of such milk is likely to result injuriously.

The Act also makes provision for the cleansing and disinfection of premises, or of any articles likely to retain infection, to the satisfaction of the Medical Officer of Health.

One of the most important sections prohibits the retention of dead bodies in dwelling-rooms, or sleeping-rooms, or workrooms, for more than forty-eight hours, and provision is made that the bodies of persons dying of infectious disease in hospitals shall only be removed for burial, and shall not be taken back to a dwelling-house.

CHAPTER X.

FOOD, MORBID CONDITIONS OF FOOD AND THEIR CONSEQUENCES; CLOTHING.

FOOD.

1. *Food and Diet.*—Foods are substances which are capable of undergoing such changes in the digestive organs as will render them capable of absorption into the circulation, and of serving one or other of the following purposes, viz.:—

(*a*) Of renewing the tissues and the organs of the body;

(*b*) Of supplying material for the maintenance of their functions.

In other words, they are either tissue producers or force producers, but most of the ordinary articles of diet contain both materials, although in unequal proportions, and ordinary articles are therefore to a certain extent contributory not only to the growth, maintenance, repair, and functional activity of the tissues, but also to the production of heat and force. Water also enters largely into the composition of all foods, and is essential to their assimilation; a certain quantity of salts is also present in foods. Besides foods proper, certain food accessories are in constant use, such as tea, coffee, alcohol, condiments, etc. Organic food-stuffs admit of a division into the nitrogenous, and the non-nitrogenous. The nitrogenous, as the name implies, contain nitrogen; their function is mainly that of providing for growth, maintenance, and repair, and only in a minor degree do they contribute to the production of heat and force. As a common illustration of the various kinds of nitrogenous food-stuffs may be mentioned (1) egg albumen, (2) myosin, the chief constituent of meat, (3) casein, from milk in cheese, (4) legumin, from peas, beans, etc., (5) gluten, in cereals, wheat, bread, (6) peptones, which include the foregoing after they are rendered diffusible and non-coagulable by heat,

by the gastric juices. The non-nitrogenous food-stuffs include the fats or hydro-carbons, and also the starches and sugars or carbo-hydrates. These contain no nitrogen, and are used up in the production of heat and force, or in the formation of fat in the body. Water and the inorganic salts are essentials in all diets.

It is obvious, therefore, that a variety of the ordinary food-stuffs is necessary to maintain health and life, and the actual diets taken by an individual include very complex mixtures. Actual diets and dietaries vary in accordance with the age and sex of the individual, with the climate and temperature, with rest and work, as well as with individual tastes and idiosyncrasies.

Standard diets have been compiled for the use of schools, hospitals, and so forth, but it is abundantly plain that what is enough in the case of one child would be too much for another, and *vice versa*. Roughly speaking, the average diet of an adult in 24 hours would comprise 4 to $4\frac{1}{2}$ ozs. of nitrogenous food (meat), 3 ozs. of fat, 15 ozs. of sugars and starches, etc., and $1\frac{1}{4}$ ozs. of salts. The average child would probably take about three-fifths of that amount, but the fats and the starches would be increased somewhat in cold climates, and this estimate does not include the food accessories.

It must be remembered that during childhood, growth and development of the nervous, muscular, and bony tissues call for an adequate food supply, and this would indicate an addition to what is wanted merely to maintain the equilibrium of the body. Milk, which is considered by some as the type of a perfect food for children, contains:—

Casein	4·0 per cent.
Fat	3·7 ,,
Sugar	4·8 ,,
Salts	0·7 ,,
Water	86·8 ,,

The probability is that milk is too dilute a food for average children of the school age.

A most important point in connection with foods is their digestibility. It is perfectly obvious that good food, unless prepared in such a way as to be digestible and attractive, loses much of its usefulness. For example, most people have a practical acquaintance with the relative digestibility of tough

meat and tender meat. A point of equal importance is that the meals should be suitably divided; excess at any time is bad. Sleep diminishes digestion, therefore late and heavy suppers should be avoided, and the reason why they cause sleeplessness is that the digestive system is given work to do at a time when it also wants sleep. It must also be remembered that active mental work immediately after a meal will retard digestion. Alcohol should never be given to children excepting as a medicine and under the advice of a medical man.

The requirements of the economy that food has to meet are those which constitute the physiological phenomena of the life of animals—the development of heat, which the body requires for its maintenance, and also the production of nervous and muscular power. Food, therefore, contains the potential energy which, by processes acting within the body, is converted into actual energy—the sum of which we call life.

The potential energy of meat-food is greater than the energy it develops, because thorough oxidation of all the albumen can never occur, for some of the constituents of the albumen always pass out incompletely oxidised in the form of urea. The potential and the actual energy of sugar are, however, practically the same; for it is, as a rule, perfectly oxidised in the body, passing off as carbonic acid and water. Professor Frankland, by means of a calorimeter, has experimentally determined the actual amount of force evolved during the oxidation of various organic materials. The substance examined is deflagrated with a mixture of chlorate of potash and peroxide of manganese in the calorimeter, and the heat evolved measured by the increase in temperature of a known quantity of water.

The following table from Pavy gives his results:—

	Units of Heat evolved by oxidation of 15·422 grains as consumed within the body.
Grape sugar (commercial)	3277
Starch (arrowroot)	3912
Albumen (purified)	4263
Fat (beef fat)	9069

"The actual energy," says Frankland, "developed by the combustion of muscle in oxygen represents more than the amount of actual energy produced by its oxidation within the body, because, where muscle burns in oxygen, its carbon is

converted into carbonic acid, and its hydrogen into water—the nitrogen being, to a great extent, evolved in the elementary state; whereas, when muscle is most completely consumed in the body, the products are carbonic acid, water, and urea—a substance which still retains a considerable amount of potential energy."

Serious mistakes would, however, follow on the formation of a dietary based on the potential and actual energy of different articles of food; for it is found that substances which differ but slightly in their potential energy cannot be substituted the one for the other.

The relative values of food of the same class are also a matter of opinion, and both vegetarians and meat-eaters claim advantages for their respective diets. But whichever diet be adopted, two conditions are absolutely necessary—that the food be in a fit state for digestion, and that the secretions which it meets with in the alimentary canal be in a healthy condition to digest it, and prepare it for its ready absorption.

Another practical consideration enforced by all writers on diet is, that care must be taken to provide variety in the articles used as food so that they should contain the proper dietetic proximate principles.

The composition of milk has been suggested as the type on which a diet table should be formed.

Classification of foods based on the chemical nature of the principles:—

1. ORGANIC.
   - (*a*) Nitrogenous.—Albumen, etc.
   - (*b*) Non-Nitrogenous.
     - 1. Hydro-Carbons or Fats.
     - 2. Carbo-Hydrates or Sugars.
2. INORGANIC.
   - (*a*) Water.
   - (*b*) Saline Substances, etc.

It has also been found that it is impossible to substitute one constituent of food for another; all are essential, and health can only be maintained by a due proportion of each in the diet. With regard, however, to vegetable and animal albuminates, it appears that these can be substituted for each other, and that nitrogenised vegetable products can replace animal products of the same nature. Animal food is more readily digested than farinaceous, and therefore supplies the wants of the system quicker; but, on the other hand, it has

been asserted that the waste is greater in meat-eaters than in vegetable-feeders. The interchange between the fats and the carbo-hydrates does not appear possible ; and with the admission that the subject is very obscure, I think we are not entitled to assert that the two groups of fats and carbo-hydrates are not so immediately and completely convertible as to permit us to place them together in a classification of diets (PARKES).

According to the same writer, during labour the muscles appropriate nitrogen, and grow instead of becoming wasted by oxidation and parting with their nitrogen, and that exhaustion does not so much depend on decay as upon the accumulation of the oxidised products of other kinds of food within their tissues. At one time it was also held that before the dynamical energy of the nitrogenous constituents of food could be obtained, they had to be converted into muscular tissue. The experiments of Drs. Fick and Wislicenus during their ascent of the Faulhorn showed that a non-nitrogenous diet will sustain the body for a short period during exercise without a notable increase in the amount of urea excreted. Some decay of muscles does, however, take place if labour be long continued, and the amount of nitrogen must therefore from time to time be given if the work continue. The amount, however, of urea excreted during exercise appears to be more in relation to the amount of nitrogenous food taken than to the oxidation of muscular tissue to which muscular action was once ascribed. Hence, the amount of urea excreted is no index of the muscular work done. Some portion of the nitrogenous substances taken as food is most probably converted in the body into fat.

The experiments of Pettenkoffer and Voit go to show that nitrogenous substances have a direct or indirect influence on the oxidation of the other constituents of food, and that their participation is necessary for the manifestation of force. But for the mere production of force nitrogenous matter is far inferior to the hydro-carbons and carbo-hydrates, and it is not to the oxidation of muscular tissue that we are to look for the force produced. The muscles appear to be the instruments by which the force generated by the oxidation of non-nitrogenous matters is converted into working power. During oxidation a certain amount of heat is evolved, which becomes transformed into motive power, and this is expressed in foot-

pounds, or the power required to lift one pound one foot high per unit of time—the unit of work.

According to Mr. Joule, 772 foot-pounds represent the dynamic equivalent of 1° F.; that is, the heat required to raise the temperature of one pound of water 1° F. constitutes the equivalent of power required to lift one pound 772 feet high. By measuring with the calorimeter the amount of heat evolved by the complete oxidation of different substances, Frankland was enabled to calculate the force-producing value of various articles of food.

The nutrient value of food has been classed under two heads—nitrogenised, or "flesh-forming," and carbonaceous, or "heat and fat producing"; but such a hard-and-fast classification is probably incorrect. The nutritive value of food is generally written in grains of nitrogen and of carbon. The daily diet of an adult man, according to Dr. Edward Smith, should contain at least 4300 grains of carbon and 200 of nitrogen; but this appears too low, Dr. Letheby considering that an adult in active employment ought to have 6823 grains of carbon and 391 of nitrogen.

These statements have been borne out by experiments made to ascertain the amount of carbon and nitrogen excreted under different conditions of diet and exercise. Two pounds of bread and three-quarters of a pound of meat will just about supply the daily amount of nitrogen and carbon required.

In the formation of a dietary, the following points have to be considered:—

1. Sex.—The dietaries of women should be one-tenth less than those of men.

2. Age.—A child at ten years of age will require half as much food as an adult woman, and at fourteen quite as much. Young men require almost as much food as adult men if engaged in the same employment.

3. Selection.—Variety, digestibility, relative proportions of proximate principles, number and distribution of meals.

The above will all require the careful attention of the medical officer of health, for Dr. Wilson found that, in convict prisons, those engaged in hard labour lost weight on a diet of 225 grains of nitrogen and 5289 grains of carbon, and had from time to time to be shifted to light work to recruit; while those on light labour found a diet of 224 grains of nitrogen and 4651 of carbon sufficient to maintain health and bodily vigour.

The following table is from Moleschott, adopted by Parkes:—

Standard Diet for a Male European Adult of Average Height, 5 ft. 6 in. to 5 ft. 10 in., and Average Weight, 140 lbs. Avoir. (66 kilogram.) to 160 lbs. (72·7 kilogram.), in Moderate Work.

Dry Food.	Oz. Avoir.	Grains.	Grammes.
Albuminous substances	4·587	2006	130
Fatty substances	2·964	1296	84
Carbo-hydrate substances	14·257	6234	404
Salts	1·058	462	30
Total water-free food	22·866	9998	648

Allowing for the quantity of fluid taken daily, the diet in the above table represents the amount of force produced equal to 3900 foot-tons (Pavy).

The force produced by the oxidation of one ounce (437·5 grains) as consumed within the body—

	Foot-tons.
Albumen (purified)	162·20
Fat (beef fat)	351·56
Starch (arrowroot)	157·66

This table gives the potential energy expressed in foot-tons of the following substances—

	Foot-tons.
One ounce of uncooked beef yields	50
,, cooked meat	160
,, dried bacon	179
,, bread	88
,, oatmeal	130
,, potatoes	33
,, butter	339
,, eggs	68
,, milk (cow's)	27
,, sugar (lump)	129·5
,, arrowroot (starch)	151·3
,, ale	30
,, porter	41·3
,, albumen (dry)	174·0
,, fat	378·0

In estimating the nutritive value of food, the value should be calculated from an analysis of the raw materials.

The following abridged table is taken from Dr. Letheby's work on Food :—

	Grains per pound.	
	Carbon.	Nitrogen.
Split peas	2699	248
Oatmeal	2831	136
Indian meal	3016	120
Seconds flour	2700	116
Potatoes	760	22
Baker's bread	1975	88
Turnips	273	13
New milk	599	44
Cheddar cheese	3344	306
Mutton	1900	189
Beef	1854	184
Fat pork	4113	106
Bullock's liver	934	204
Beer and porter	274	1
White fish	871	195
Skimmed milk	438	43

From the above table the amounts of carbon and nitrogen in any given diet may be calculated.

How much cooked beef and bread is required to provide enough nitrogen and carbon per day in model proportions for a healthy adult in average work?

(1) Bread contains per ounce, N 5 grains, C 120
(2) Beef ,, ,, N 15 ,, C 64

Let x = amount of beef in ozs. Let y = amount of bread in ozs.

Normal diet—300 grains nitrogen, 4800 carbon.

$$(1)\ 15x + 5y = 300$$
$$(2)\ 64x + 120y = 4800.$$

Multiply (1) by 64 and (2) by 15.

$$(2)\ 960x + 1800y = 72000$$
$$(1)\ 960x + 320y = 19200.$$
$$1480y = 52800$$
$$y = 35{\cdot}675.$$

In (1) If $y = 35{\cdot}675$
$5y = 178{\cdot}375$
$\therefore 15x = 121{\cdot}625$

Since $15x + 5y = 300$
and $5y = 178{\cdot}375$
$\therefore 15x = 121{\cdot}625$
and $x = 8{\cdot}1083$.

Ans. $x = 8{\cdot}1083$ oz.
$y = 35{\cdot}675$ oz.

In some calculations it may be necessary to determine the percentage composition of a substance. This may be done by the following simple rule :—To find the percentage composition of a compound from its formula, multiply the amount of each element present by 100 and divide by the molecular weight of the compound. Thus, required percentage of nitrogen in urea—

Urea, $CO\,N_2\,H_4$

$$\begin{aligned} C &= 12 \times 1 = 12 \\ O &= 16 \times 1 = 16 \\ N_2 &= 14 \times 2 = 28 \\ H_4 &= 1 \times 4 = 4 \\ &\overline{\quad 60} \end{aligned}$$

60 : 100 : : 28 : x. $x = 46{\cdot}67$ per cent of N.

A man is allowed 6 oz. of meat and 20 oz. of bread per day ; how much oatmeal must be added in order that the albuminoids in his diet may be sufficient? Would the diet thus constituted contain sufficient fat?

Composition per cent—

	Albuminoids.	Fat.
Meat	15	8
Bread	8	1·5
Oatmeal	12	6

	In work.	Idleness.
Daily requirements of albuminoids	4·48	2·73
,, ,, fats or carbonaceous food .	26·44	20·60

Meat, 15 per cent of 6 oz. = ·9
Bread, 8 ,, 20 oz. = 1·6

2·5

Required amount of albuminoids . . 4·48
2·5

1·98 still required.

Oatmeal, 12 per cent.

The number, multiplied by ·12, which will give 1·98 is 16, hence 16 oz. of oatmeal required.

The fats are in excess—

8 per cent of 6 oz. = ·48
1·5 ,, 20 oz. = 30·48

26·44
30·00

4·04 fat in excess.

One other subject remains for consideration. What is the dietetic value of alcohol? On this most important subject no two opinions agree, but it appears certain that in very cold and in very hot climates the use of alcohol is positively injurious.

The following are the physiological and dietetic values of alcohol as summed up by Dr. T. L. Brunton:—

1. Alcohol, in small quantities, increases the secretion of the gastric juice and the movements of the stomach, and thus aids digestion. Although unnecessary to health, it is useful in exhaustion and debility.

2. It increases the force and frequency of the pulse, by acting reflexly through the nerves of the stomach.

3. In large doses it impairs digestion by over-irritating the stomach.

4. After absorption into the blood, it lessens the oxidising power of the red blood cells. This property renders it useful in reducing the temperature. When constantly, or very frequently, present in the blood, it causes accumulation of fat and fatty degeneration of organs.

5. It undergoes combustion in the body, maintains or increases the body weight, and prolongs life on an insufficient diet. It is therefore entitled to be reckoned as a food.

6. If large doses be taken, part of it is excreted unchanged.

7. It dilates the blood-vessels, increases the force and frequency of the heart by its action on the nervous centres, to which it is conveyed by the blood, imparts a feeling of comfort, and facilitates bodily and mental labour. It does not give additional strength, but merely enables a man to draw upon his reserve energy. It may thus give assistance in a single effort, but not in prolonged exertions.

8. The same is the case with the heart; but in disease, alcohol frequently slows instead of quickening the pulsations of that organ, and thus economises instead of expending its reserve energy.

9. By dilating the vessels of the skin, alcohol warms the surface at the expense of the internal organs. It is thus injurious when taken during exposure to cold, but beneficial when taken after the exposure is over, as it tends to prevent congestion of internal organs.

10. The symptoms of intoxication are due to paralysis of the nervous system; the cerebrum and cerebellum being first affected, and then the cord, and lastly the medulla oblongata. It is through paralysis of the medulla that alcohol usually causes death.

11. The apparent immunity which drunken men enjoy from the usual effects of serious accidents is due to the paralysis of the nervous mechanism, through which a shock would be produced in a sober condition.

Characteristics of Good Meat.

Good and wholesome meat—*beef* or *mutton*—should present the following characters, which can be very readily observed :—On section, good meat should present a marbled appearance, and be of a pale, slightly brownish-red colour, neither too pale a pink nor too dark a purple. If pink and moist, disease is indicated ; if purple and livid, it suggests that the animal most probably died with the blood in it, or had suffered from fever. The meat from healthy *slaughtered* animals should be firm and elastic, have little or no odour, and should dry on the surface if kept a day or two. Bad meat may easily be known by a moist and flabby appearance, accompanied with a sickly odour, which may be more easily detected by chopping up portions of the meat and drenching it with warm water. A clean knife may be plunged into the meat and then put to the nose, when any taint will be detected. Good meat should not shrink or waste much in cooking. The juice should be neither alkaline nor neutral, but slightly acid.

Pork, not salted, should, in all respects, resemble other good meat, excepting the colour, which ought to be a very pale red tint when sound. When of a dark colour, the presence of the dangerous parasite *Trichina spiralis* may be suspected, and the meat most carefully examined by means of a magnifying glass, as the unaided eye cannot be relied on. The sac of the *Cysticercus* or measle, which is often as large as a hemp seed, is easily seen, especially in the psoas muscles.

MORBID CONDITIONS OF FOOD AND THEIR CONSEQUENCES.

EXISTENCE OF PARASITES.

1. *Measly Pork.—Cysticercus cellulosis*, found in all parts of the flesh. Worm enclosed in a bladder about the size of a hemp seed ; rare in sheep and oxen. The measles worm of the pig becomes the *Tænia solium* in man, that of oxen the *Tænia medio-canellata.* Cooking destroys the worm.

2. *Trichiniasis.—Trichina spiralis*, found chiefly in the pig as a spiral worm in a calcareous cyst. If these enter the stomach of man, the cyst is dissolved, worm set free, produces young in large quantities, which then migrate to the muscles,

causing severe fever, pain, and death. Cooking, unless *perfect*, does not destroy the worm. Salting is useless.

In anthrax, advanced pleuro-pneumonia, advanced tuberculosis, and swine fever, the whole of the carcase should be destroyed.

In the early stages of tubercle there is no evidence of injury from the consumption of the carcase, assuming that the lesions are limited to certain organs.

Animals which have died or have been killed by accident should be rejected, unless immediately after the accident the animal has been bled.

Decomposed meat must be carefully guarded against; tinned meat, cold pies, more especially veal or pork, which have been kept too long, may contain injurious organisms or ptomaines.

Milk is a frequent vehicle of disease, and very commonly the medium of choleraic diarrhœa to infants, owing to its decomposition in dirty bottles and dirty tubes. Sterilised humanised milk is prepared in some large centres of population, and its use is attended with great benefit.

CLOTHING.

The blood of man remains nearly at the same temperature irrespective of the changes of temperature to which he may be subjected. By the use of clothes, man adapts himself to all temperatures and counteracts by their use the loss of heat by radiation, evaporation, and conduction. The heat of his body is radiated to the inner surface of his garments, and then passes through and from them by conduction and radiation. The heat is therefore, by the use of clothes, kept longer near our bodies—the thinnest veil keeping the face warm by arresting the radiated heat. The textures most permeable to air keep us warmest, air being one of the worst conductors of heat; uncompressed wadding is, therefore, warmer than when compressed. The air which reaches our bodies has also been prepared for us by our clothes, and the differences of temperature between our bodies and the surrounding atmosphere equalised in the meshes of the cloth. Clothes act on the same principle as the double window-sashes used in cold climates—the layer of air between them keeping the heat in the room. Our clothes do not therefore keep us warm by excluding air

from our bodies, for were this so, kid would be warmer than flannel. Tight-fitting clothes are not so warm as loose-made ones. The heat of animals is maintained by the air in their fur, which never becomes cold except at the tips. India-rubber clothes prevent evaporation by limiting the change of air in the under garments; they therefore become inconvenient in damp, warm weather, but may be worn in wet, cold, windy weather. Wet clothes, the air in their meshes being displaced by water, keep us less warm than when dry, because water is a better conductor of heat than air, and the evaporation of the water in them also cools the surface of the body. Hence also the ease with which we take cold in wet linen or silk as compared with wool, which absorbs water slowly. Wool should always be worn next the skin, but it is needless to point out that in summer the woollen garment should be an exceedingly thin one; the disadvantage of wool is the way in which the soft fibre shrinks, hardens, and becomes less absorbent after frequent washing. The quicker the air is expelled the more likely are we to take cold, as the body chills rapidly. Our bed-clothes should be light, airy, and warm. There is a constant circulation of air from the bottom to the top of the bed; and as during sleep less animal heat is produced, the appropriateness of the bed-clothes becomes even more important than our day clothes.

Clothing should never fit so tightly as to constrict; loosely-fitting clothes are more comfortable and warmer, as they imprison the air. Tight gloves will produce chilblains. Braces should be worn rather than belts or garters. Young children should be properly covered in cold weather; bare arms, chests, and legs should be avoided. Children should never be allowed to sit in damp clothes. Frequent changes of underclothing are necessary, and things worn by day should never be slept in at night.

Boots should have thick, damp-proof soles, low heels, and should fit comfortably.

CHAPTER XI.

SCHOOLS, CHURCHES, AND THEATRES.

In schools, churches, and theatres a system of thorough ventilation is absolutely necessary; and, in the case of theatres, care should be taken that the means of egress in case of fire is easy of access.

A proposal has been presented to the Massachusetts State Board of Health by Mr. Martin, architect, for ventilating the school-rooms of Boston by means of a ventilating shaft—the impure air being removed from the room through openings under the scholars—fresh air, properly warmed, being admitted from the roof. Mr. Martin refers the injurious effect of bad ventilation, not so much to the carbonic acid present in the air, as to "the watery vapour and the animal matter thrown off both by lungs and skin, which seem to putrefy almost immediately after being thrown into the air."

Lighting.—The window area has been stated to be from one-fourth to one-tenth of the floor area, or the square root of the length, breadth, and height multiplied together. The light should never enter in front of the scholars, nor from the back if possible, as it causes the scholar to sit in a twisted position to keep his book out of shade. The best light is that provided from the left, and the height of the sills of the windows should never be less than five feet from the floor. Lighting from both sides may be allowed if the room be very large, and the light from the left side be the stronger.

Desks.—Besides the questions of lighting, ventilation, etc., there are other sanitary matters connected with schools that demand a brief notice. Eulenberg states that 90 per cent of curvatures of the spine, not caused by actual bone disease, are

developed during school life. A flat desk is bad, necessitating a cramped position interfering with free respiration; and a desk too far from the seat has a tendency to cause a forward stoop, flat chest, round shoulders, and injury to the eyes. The slope of the desk should be capable of change—for writing, an angle of 30° should be adopted, and one from 40° to 45° for reading.

SEATS.—These should be adapted to the height of the scholars. If too high, the feet swing and the vessels and nerves at the back of the legs are compressed, especially if the seat is too narrow. If the seat be too low, the thighs are bent up to the body. The *height* of the seat should be equal to the length of the leg from the sole of the foot to the knee, and its *width* not less than eight inches. Backs should be provided to each seat. Liebriech states that the top of the back of the seat should be an inch lower than the edge of the desk for boys, and an inch higher than the same point for girls. The distance between the seat and top of the desk should be the length of the forearm, or one-sixth the height of the scholar. The edge of the seat should be directly under the edge of the desk, or at least not more than an inch should intervene between the points above stated.

The Law with regard to Schools during Epidemics.—Schools may be closed by order of the Local Authority during the prevalence of epidemics, and in such cases a proportionate reduction is made from the number of meetings required to qualify for the Parliamentary grant. The managers may appeal to the Education Department if they consider the closing of the school by the Local Authority unreasonable.

Sunday schools, "dames'," or private schools, are not subject to the authority of the Local Authority, unless they contravene sections 91 to 126 of the Public Health Act, 1875.

Sickness in Schools.

The ailments which may lead to the closure of the school, or the exclusion of the scholars therefrom, are not limited to diseases scheduled under the Infectious Disease (Notification) Act. In fact, quite apart from actual illness among the scholars, there is a phrase "or in danger to health likely to arise from the condition of the school."

The diseases on account of which it is most usually necessary to exclude scholars, or close schools, are those which spread directly from person to person, such as scarlet fever, measles, diphtheria, whooping-cough, smallpox, typhus fever; and it is also very commonly necessary to exclude pupils coming from homes in which typhoid fever, or certain forms of choleraic diarrhœa exist—one reason, in the case of typhoid fever, being the risk of contamination of the closets by a child in an incipient stage of the illness.

In all forms of acute illnesses, which may possibly develop into infectious disease, it is desirable to exclude scholars coming from houses where sickness is until it is clearly ascertained that the disease is not an infectious one. It must be remembered that in their early phases some forms of infectious sickness are frequently obscure and difficult to diagnose; consequently it is better that the error should be on the side of safety, and the child excluded if the circumstances of illness at home are doubtful.

Very frequently teachers will be the first persons who have the opportunity to notice symptoms of illness in a pupil. A change in the normal disposition of the child, abnormal irritability, drowsiness, or inattention, are commonly associated with impending illness; hot and dry skin, accompanied perhaps with shivering; shrunken and dusky, or flushed appearance of the face; complaint of headache, sore throat, diarrhœa, or pain, should be carefully observed by the teacher, and the pupil should temporarily be taken from the class for medical examination if necessary. These observations are specially necessary during times of prevalence of infectious sickness, the onset of which is commonly attended by one or more of the symptoms alluded to; those first named are practically common to them all, but during times of prevalence of scarlet fever or diphtheria, every case of sore throat is to be looked upon with suspicion, and children with rashes on the skin should be promptly separated from the class.

The importance of attention to these matters will be more apparent when it is remembered that when an infectious disease has been contracted a period of incubation ensues, of varying duration, before any symptom of illness is manifested by the infected person. Hence, when a child has been exposed to infection it is unsafe for that child to mix with others until it

is evidenced by expiration of the period of incubation that the child has not been affected.

The period of incubation and the average duration of infectivity of the commoner forms of infectious disease are as follows, but it is desirable that exclusion from school should not be limited to minimum periods, but continued for fourteen days after disinfection has been completely carried out by a competent authority, or until, of course, the child is strong enough to resume school work.

	Average Incubation Period.	Average Duration of Infection from Commencement of Illness.
	Days.	Weeks.
Scarlet fever . . .	4	5 to 8
Diphtheria	4	3
Measles	12	3
Whooping-cough . .	14	7
Typhus fever . . .	10	5
Typhoid	...	5
Rötheln	8	3
Mumps	14 to 21	4
Smallpox	12	4 to 12[1]
Chicken-pox . . .	12	6

[1] Varying as the disease has been modified by vaccination.

Ringworm, scabies, and ophthalmia may last indefinitely unless properly dealt with, and no child with any trace of these diseases should be admitted to school.

The influence of school closure upon the prevalence of sickness is treated under "Prevention of Spread of Diseases," p. 634.

With reference to the grounds upon which scholars should be excluded from school, it must be admitted—

(1) That all children suffering from an infectious disorder should be excluded from school so long as they are likely to retain any infection; this condition is one which may involve exclusion for some time after the patient is apparently convalescent.

(2) In general practice it is equally necessary that children coming from houses, any inmate of which is suffering from

infectious sickness, should also be excluded, because in the great majority of instances, if not in all of them, it is impossible to effectually isolate a case of infectious sickness in an ordinary household, especially within the homes of children of the class who attend the public elementary schools.

Hardship really is minimised by a careful application of the powers to exclude individual scholars, because unless this is attended to it is quite possible that disease may rapidly spread to an extent which would render it necessary to close the school altogether.

It must not be forgotten that the sanitary authority of every town and of most rural districts has provided hospitals for the isolation of those suffering from infectious disease, and if the patient is removed to hospital, and the house, etc., disinfected, attendance at school may be resumed by children living in the house much sooner than if the patient remains at home throughout the entire illness.

The closing of schools may seriously interfere with the educational work of the locality, and is a step which should only be taken after the most careful consideration of the circumstances, and upon evidence that extension of disease will be checked by it.

The character of the evidence that the school is the centre of infection must be carefully weighed, and the nature of the action to be taken will necessarily vary under different conditions. If, for example, a serious and formidable form of disease is found to be spreading amongst children living at such distances apart as to render it improbable that they had any other means of communication than that involved by attendance at school, grounds would be furnished for the suspicion either that some coming from an infected house were disseminating the disease, or possibly that a child actually in an infectious condition was attending the school. Localised outbreaks of typhus fever, for example, a most formidable and dangerous disease, have been definitely traced to these causes, and it must be remembered also that even if other possible opportunities for infection exist, such as would arise in playing together or going to one another's houses, it must be borne in mind that the relationships are less intimate than when in school.

It is extremely difficult, if not impossible, to lay down

definite rules as to when, and for how long a time, schools should be closed. The nature of the disease, its character, the numbers of the pupils affected, will all be factors in determining the point, as well as the nature of proof that the sources of infection are actually at the school.

It is plain, for example, that if 10 per cent of the children attending a school are absent on account of typhus fever, the aspect is more grave than if the same number of children are absent from measles, and the more formidable character of the one form of disease would call for more stringent action than in the case of the other ; yet in either case it would be necessary to adopt as rigorous means as possible to exclude scholars from infected houses in the first instance, and it would probably be found in that way that the disease would be checked without resorting to closure of the school.

Much depends upon the amount and the promptness of the information which the Medical Officer of Health is able to gain in regard to the circumstances of the school children and their homes, and the promptness with which action can be taken.

Closure of schools is less likely to be efficacious in checking diseases such as measles in a densely-populated district than in a sparsely-populated one, because the opportunities for intercommunication in other ways are much greater in the densely-populated district than in the rural one, where children live at greater distances and are less likely to meet together apart from schoolroom meetings.

The existence of infectious disease in a locality is by no means *per se* to be looked upon as a ground for closing the schools, and again still less is the existence of isolated cases of sickness amongst the pupils.

What applies to public elementary schools (Board schools and denominational schools) also applies to Sunday schools and private schools. Although these latter establishments are not subject to the same regulation by the sanitary authority as the others, yet the Public Health Act does make certain provisions which are applicable to schools of every kind, and the managers of these establishments are, as a rule, perfectly willing to act upon the suggestions which the sanitary authority may find it necessary to offer.

When it does become expedient to close schools it is desirable

that the time specified should be a minimum, because if it appears necessary a notice extending the period can be given before the expiration of the time originally stated.

DISPOSAL OF THE DEAD.

The disposal of the dead is a matter of considerable importance to the well-being of a community. The following methods have been adopted:—(1) Embalming, (2) Cremation, (3) Sea-burial, and (4) Land-burial.

Cremation, from a sanitary point of view, is by far the best way of disposing of the dead, and public prejudice against the proceeding is lessening.

Sea-burial can only be adopted in towns on the coast, as the expense would be too great when the body has to be carried any distance. *Embalming* is never likely to be adopted by modern nations.

Land-burial, which, from a sanitary point of view, is the worst of all forms of burial, will most probably last the longest of any, till the public mind by degrees becomes tutored to an enlightened appreciation of the sanitary benefits of cremation.

Burial in the ground is open to the following objections:—

(*a*) That the air over churchyards and cemeteries is charged with carbonic acid, ammonia, and an offensive putrid vapour. From the churchyards of London it has been stated that $2\frac{1}{2}$ million cubic feet of carbonic acid gas were given off yearly by 52,000 bodies buried in the yards.

(*b*) That disturbance of these grounds gives rise to disease.

(*c*) That wells and other sources of water supply are contaminated by impurities percolating through the soil.

The following remedies have been suggested:—

(*a*) The removal of burying-grounds to some distance beyond the town.

(*b*) Burying the body as deeply as possible, and only one body in each grave. This rule is broken daily in the cemeteries round London; four or five bodies in the same grave is not unusual.

(*c*) The use of plants of quick growth and dense foliage, which purify the air by absorbing the organic substances and the carbonic acid.

(*d*) Careful selection of the site and soil. In selecting a site for a cemetery, a declivity facing the north or north-east is to be preferred. The drainage of the soil is thus facilitated. The soil, if selection is permitted, should be dry and well drained, care being taken that the drainage does not have access to any stream or well from which water is drawn for domestic purposes. A porous, coarse-grained, gravelly soil

should be selected, stiff clay or marly soils rejected, for the future site of a cemetery. All soils containing much water should be extensively under-drained. No body should be buried at a less depth than six feet from the surface, and the more perishable the coffin the better. Houses should not be nearer the walls of a cemetery than 500 yards—a rule seldom kept, for near London the site of a cemetery seems to have an attraction for the builders of "suburban villas." In calculating the area required for a town, take the death-rate at 30 per 1000, and allow two square yards for each grave, that is, for the grave and space between it and the next. Another method of calculation is to allow a quarter of an acre of burial space to each 1000 head of population. This is, however, not enough where the soil is unfavourable, and extensive pathways are allowed. The space given above may with advantage be increased by 50 per cent, or say half an acre per 1000.

The following are the regulations issued by the Home Office in 1863 under the Burial Acts :—

The grave spaces for persons above twelve years of age shall be at least 9 feet by 4 feet (4 square yards) ; under twelve years of age (6 feet by 3 feet or 4½ feet by 4 feet (2 square yards). There must be at least a foot between each grave.

No unwalled grave shall be reopened within fourteen years after the burial of a person above twelve years of age, or within eight years under twelve, unless to bury another member of the same family, in which case a layer of earth not less than one foot thick shall be left undisturbed above the previously buried coffin.

No coffin shall be buried in any unwalled grave within 4 feet of the surface of the ground, unless it contains the body of a child under twelve years of age, when it shall not be less than 3 feet below the level.

APPENDIX.

Some facts of interest to the student are here inserted :—

TO FIND THE CIRCUMFERENCE OF A CIRCLE.

$$D \times 3{\cdot}1416.$$

TO CALCULATE THE REQUIRED THICKNESS OF A PIPE.

Multiply the pressure in pounds per square inch by the diameter of the pipe in inches, and divide the product by twice the tensile resistance of a square inch of the material of which the pipe is constructed.

PRESSURE ON THE SIDES OF VESSELS.

The side of any vessel sustains a pressure equal to its area multiplied by half the depth of the fluid, and the whole pressure upon the bottom and against the sides of a vessel is equal to three times the weight of the fluid.

PRESSURE ON THE BOTTOM OF A CONICAL, PYRAMIDAL, OR CYLINDRICAL VESSEL.

The pressure is equal to the area of the bottom and depth of the fluid.

THE STORAGE OF WATER.

$$D = \frac{1000}{\sqrt{F}}$$

D = number of days' supply to be stored.
F = mean rainfall in inches for three consecutive dry years.

TO FIND THE SPECIFIC GRAVITY OF ANY SOLID OR FLUID

Divide the weight in pounds avoirdupois of a cubic foot of the body, whatever it may be, by 62·32, the weight in pounds avoirdupois of a cubic foot of distilled water, and the quotient obtained will be the specific gravity of the body.

TO FIND THE WEIGHT OF A CUBIC FOOT OF ANY SOLID OR LIQUID

Multiply the specific gravity of the body by 62·32, and the result obtained will be the weight of a cubic foot of the body in pounds avoirdupois.

BRICK AND IRON STOVES.

Brick, although a worse conductor of heat than iron, yet parts with heat from its suface more readily than the latter material. Owing to its slow conductibility, it warms the air more equably than iron ; at the same time it does not allow of the passage of obnoxious gases generated during perfect or partial combustion. Iron stoves, allowed to get red hot, transmit carbonic oxide from the fire, or even manufacture it from the carbonic acid in the air.

FLOUR.

The cold aqueous extract of flour is obtained by digesting 10 grammes of flour in 500 c.c. of water, filtering, and evaporating down to 250 c.c. One hundred grammes of flour yield to water—

	Grammes.
Sugar, gum, dextrine	3·33
Vegetable albumen	0·92
Phosphate of potash	0·44
	4·69

On ignition the ash should consist entirely of phosphate of potash, from which the phosphoric acid may be estimated. The sugar may be estimated in the usual way from the residue before ignition, but the determination of the weights of the old extract and the ash is as a rule sufficient.

BREAD.

The amount of water in bread may be determined by carefully drying 25 grains of bread till they cease to lose weight. Forty-two per cent of moisture is allowed.

COWS' MILK.

The milk first drawn from a cow ("fore" milk) contains but little fat; the latter portions ("strippings") contain an excess. It consists of water, sugar, milk fats, caseine, salts, and extractive matters. Average sp. gr. 1032. The total solids are obtained by evaporating to dryness a known quantity of the milk; the solids not fat are that portion left after the fats have been dissolved out with ether. The salts are obtained by incinerating the total solids and weighing. The average percentage of the "solids not fat" is from 9·3 to 9·5; the Society of Public Analysts takes 8·5 as the minimum; the "fats" should at least be equal to 2·5 per cent.

BUTTER.

Samples of Genuine Butter—Fatty acids.

Soluble	5·92	5·76	4·77	per cent.
Insoluble	87·86	88·10	88·44	
	93·78	93·86	93·21	

Adulterated Butter.

Soluble	1·98	2·34	0·58	
Insoluble	93·30	93·82	95·51	(Butterine).
	95·28	96·16	96·09	

(Blyth.)

Butter containing crystals is probably adulterated.

The caseine should average about 2·5 per cent, but it may amount to 6 or 7 per cent.

The specific gravity should not be below ·91101; and the melting point about 35·8° C. Any degree below this points to butterine or margarine, 31·3° C.; above, to other fats, tallow, 53·3° C.

BUTTERINE OR OLEO-MARGARINE.

This is prepared from beef fat by melting the fat and then straining it through cotton cloths, by which means the stearin is separated from the oleo-margarine. The oleo-margarine is now churned with milk to give it a flavour, coloured with annatto, rolled with ice, and made into "pats," or put into kegs, and exported.

MARGARINE ACT (50 and 51 Vict. c. 29).

This Act came into force on 1st January 1888.

"Butter" is defined as "the substance usually known as butter, made exclusively from milk or cream, or both, with or without salt or other preservative, and with or without the addition of colouring matter"; and "margarine," as "all substances, whether compounds or otherwise, prepared in imitation of butter, and mixed with butter, or not." No such substance shall be lawfully sold, "except under the name of margarine, and under the conditions set forth in this Act." Every package, open or closed, is to be branded or durably marked "margarine," on top, bottom, and sides, in printed letters, not less than three-quarters of an inch square. The marking must be clearly visible to the purchaser, and the wrapper must have the word "margarine" in printed capitals, a quarter of an inch square. Samples may be procured by any Officer of His Majesty's Customs or Inland Revenue, or any Medical Officer of Health, or Inspector of Nuisances, or police constable, authorised under section 13 of the Sale of Food and Drugs Act. All manufactories of margarine in the United Kingdom must be registered by the Local Authority. Inspectors may take for analysis samples of butter suspected of being margarine, and any substance not marked "margarine" will be presumed to be exposed for sale as butter. For the first offence, a fine not exceeding £20; for the second, not exceeding £50; and for the third, not exceeding £100. An employer is to be exempt from penalties, if he can prove that the offence has been committed by some other person without his knowledge or concurrence. The real offender is, however, to be punished. The onus of carrying out the Act is thrown on the Local Authorities.

BY-LAWS.

By-laws are the regulations made by Local Authorities with regard to certain matters—lodging-houses, offensive trades, cleansing streets, etc.

They must be confirmed by the Local Government Board, to give them authority.

Any ratepayer may inspect copy of by-laws at the office of the Local Authority at all reasonable times, free of charge. (See Local Government Board Model By-Laws.)

CELLAR DWELLINGS.

No cellar must be occupied unless—

1. Every part from floor to ceiling is 7 feet high, 3 feet being above the surface of the street.
2. Unless there is an area along the entire front, extending from 6 inches below the floor line to the level of the street, and 2 feet 6 inches wide in every part.
3. Unless well drained, the highest point of drain being at least one foot below the floor.
4. There must be a water-closet, earth-closet, or privy, and ash-pit.
5. There must be a chimney or flue, and an external window of at least nine superficial feet clear of the frame. An inner cellar, connected and used with the outer, must have a window of four superficial feet.
6. No steps or staircase must pass over in front of the window.

ALKALI ACTS, 1863, 1874.

The first Act enacts that 95 per cent of the muriatic acid be condensed; the second provides that not more than half of a grain per cubic foot of muriatic acid be allowed to escape in any air, smoke, or chimney gases from the works. The term noxious gases shall mean "sulphuric acid, sulphurous acid, except that arising from the combustion of coals, nitric acid, or other noxious oxides of nitrogen, sulphuretted hydrogen and chlorine." An "alkali work" is every work for the manufacture of alkali, sulphate of soda, or potash, in which muriatic gas is evolved. The more recent Act adds the following:—"The formation of any sulphate in the treatment of copper

ores by common salt or other chlorides, shall be deemed to be a manufacture of sulphate of soda."

BAKEHOUSE ACT, 1863.

No person under the age of eighteen may be employed in a bakehouse between 9 P.M. and 5 A.M.

The Act states that no place on a level with the bakehouse in any town over 5000 inhabitants, and forming part of the same building, shall be used as a sleeping-place, unless it is effectually separated from the bakehouse by a partition extending from floor to ceiling, and has an external glazed window of nine superficial feet, four and a half being feet made to open. All bakehouses must be kept clean, well ventilated, and lime-washed, and free from any smell from drain or privy.

THE POWERS AND DUTIES OF LOCAL AUTHORITY WITH REGARD TO SCAVENGING AND CLEANSING STREETS AND HOUSES.

POWERS.—To provide for the scavenging and cleansing of streets; to provide receptacles for deposit of rubbish; to order removal of manure, or sell the same to pay expenses of removal.

DUTIES.—To cleanse streets when ordered by Local Government Board; to see that all houses are properly cleansed by order of Medical Officer; to see that pigs are not kept so as to be a nuisance; to prevent stagnant water or sewage from a cesspool becoming a nuisance or injurious to health; to provide for the cleansing of ditches, etc.

NOTE.—The Local Authority is subject to penalty after notice from occupiers for not removing refuse if they have contracted to do so.

THE POWERS AND DUTIES OF LOCAL AUTHORITY WITH REGARD TO CELLAR DWELLINGS AND LODGING-HOUSES.

POWERS.—To close cellars in cases of two convictions; to refuse, if necessary, to register common lodging-houses; to make by-laws with regard to the same; to require water to be supplied to them; to order reports from keepers of houses taking vagrants; to make by-laws as to houses let in lodgings, if required to do so by Local Government Board.

DUTIES.—To keep register of the names and residences of

all keepers of lodging-houses; to cause notice of registration to be fixed to all lodging-houses; to see that all lodging-houses are periodically lime-washed.

NOTE.—All keepers of common lodging-houses must now give *immediate* notice to Local Authority of any infectious disease occurring in their houses.

ANALYSTS.

These are appointed under the Food and Drugs Act by the following bodies—

In England:—(*a*) The Commissioners of Sewers of the City of London and liberties thereof; (*b*) Vestries and District Boards for other parts of the Metropolis; (*c*) The Court of Quarter Sessions of every County; (*d*) The Town Council of every Borough having a separate Court of Quarter Sessions, or having, under any general or local Act of Parliament or otherwise, a separate Police establishment.

In Scotland:—(*a*) The Commissioners of Supply; (*b*) The Commissioners or Board of Police; (*c*) The Town Councils of Boroughs.

The approving Authority, in the place of the Local Government Board in England, is one of His Majesty's Principal Secretaries of State. They were first to be appointed immediately after the passing of the Act, and vacancies to be filled up as they occurred, or when required to be done, by Local Government Board.

Any persons possessing competent knowledge, skill, and experience as analysts of all articles of food and drugs sold within the district, might be appointed, but proof of competency must be supplied. The remuneration is left to the agreement of the parties. No person connected directly or indirectly in any trade or business for the sale of food or drugs in the district can be appointed analyst.

RIVERS POLLUTION PREVENTION ACT.

The object of this Act is to improve and preserve the purity and flow of rivers and streams of Great Britain. It is applicable to all rivers, streams, canals, lakes, and water-courses, with the exception of water-courses at the passing of the Act, mainly used as sewers, and emptying directly into

the sea, or into tidal waters not declared to be streams within the Act. The four sources of pollution are

(*a*) Solid refuse of manufactories, manufacturing processes, or quarries, rubbish and cinders, and any other waste or putrid matter; (*b*) Sewage matter, whether solid or liquid; (*c*) Poisonous, noxious, or polluting liquids proceeding from factories and manufacturing processes; (*d*) Solid or liquid matter from mines, which is poisonous, noxious, or polluting, or interferes with the flow of the water. "Solid matter" shall not include particles of matter in suspension in water. "Polluting" shall not include innocuous discoloration.

Proceedings may be taken in England against the person causing the pollution in the County Court of the district, or into a higher Court with the permission of the Judge of such Court. The Local Authority must take proceedings against offenders, having first obtained the permission of the Local Government Board. If the Local Authority neglect to act, any individual aggrieved may appeal to the Local Government Board, who may or may not direct the Local Authority to begin an action. Due regard will be paid to the industrial interest involved in the case, and to the circumstances and requirements of the locality. This Act applies to Scotland and Ireland.

REGULATION OF DAIRIES, COW-SHEDS, AND MILK-SHOPS.

The regulation of dairies, etc., is now, by the Contagious Diseases (Animals) Act, 1886, transferred from the Privy Council to the Local Government Board and Local Sanitary Authorities. Every Local Authority must keep a Register of persons in their district, carrying on the trade of cow-keepers, dairymen, or purveyors of milk, and it is unlawful for any person to carry on such trade unless so registered. The Act further authorises Local Authorities to make Regulations—

1. For the inspection of cattle in dairies.

2. For prescribing and regulating the lighting, ventilation, cleansing, drainage, and water supply of dairies and cow-sheds in the occupation of persons following the trade of cow-keepers or dairymen.

NOTE.—*The air space for cows should be from 800 to 1300 cubic feet for each cow. The Metropolitan regulations fix a minimum of 600 cubic feet in some cases and 800 in others.*

3. For securing the cleanliness of milk-stores, milk-shops, and of milk-vessels used for containing milk for sale by such persons.

4. For prescribing precautions to be taken by purveyors of milk, and persons selling milk by retail, against infection or contamination.

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